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MAXIM-WESTON ELECTRIC COMPANY, LIMITED.

In no kind of business are competitors proverbially affectionate, or even moderately considerate, one towards another. It is as well, perhaps, that they should not be, for where the spectacle is presented of a combination of a friendly character the suspicion that is bound to arise of the existence of a "ring" or monopoly may not be altogether unfounded. But we are glad to think that generally speaking the rivalry, keen as it may be, which exists between competing firms and companies is conducted with a certain spirit of fairness and with an essential regard for recognised business methods and principles. In these circumstances, while it may be necessary to strain every nerve in the battle for profits, there is rarely much serious friction between the contestants, and the amenities of business life are preserved upon a tolerable basis. Occasionally, however, some individual or body breaks away from the traditions observed by the general trading community, sets up a moral code of his own or for itself—a code which probably to others appears rather to be immoral—and earns, as a rule, more obloquy than profit in the end. Now, we do not mean to say that the Maxim-Weston Company has ever transgressed in this degree, or that it has been guilty of any very defined breach of the unwritten laws of the commercial world. Still, few companies professing to do a straightforward, genuine business have succeeded in getting themselves regarded by their fellow-traders with so much dislike and distrust. Here, too, the profession and the promise have been so great that we have been led to expect a more than usually strict observance of elementary business principles, and because the expectation has not been realised the disappointment has naturally been all the more severe. We have now and then had occasion to incidentally remark upon the questionable conduct of this company where competition for contracts existed, or where negotiations had already been entered upon by some other firm. The latest instance in which the Maxim-Weston Company's action has met with general condemnation in electrical circles is that of the City lighting negotiations, where its (as we think) unwarranted and ill-considered interference undoubtedly led to the abandonment of a fairly good proposal, and the postponement of the adoption of electric lighting for the greatest city of the world. These meddlings have, of course, been prompted with the view of gaining increased business for itself—sometimes we have fancied, with the view of getting business, whether or not it was likely to prove remunerative, for it has often been difficult, if not impossible, to perceive where direct profit was to be realised. There are others than the heathen Celestial who prefer ways that are dark and crooked to the straight and more palpable path, and suspicion of a preference for roundabout methods has long attached itself to Maxim-Weston management. There may have been—there must have been—ulterior objects in view which promised a reward for the present loss, or lack of profit, involved in many of the company's proposals, and it is possible that in their endeavour to be keen and far-sighted, the directors—(perhaps it would be more strictly accurate to avoid the use of the plural here, but as each member is equally responsible for that which is the adopted policy of the board as a whole, we retain it)—may have accidentally overlooked such a comparatively insignificant matter as common fairness towards fellow-traders. Be that as it may, the time of reward is not yet. Dividends have been paid, it is true; but there is no dividend forthcoming now. It has been the habit of the chairman of the company to boast of the excellent contracts which he has been in a position to secure for the company; yet now he has to confess that several important "contracts" (contemplated contracts, he probably means), the profits upon which were counted on to make up the dividend for the past year, have fallen through completely, with the consequence that no dividend can be paid. The story told by Mr. Watt in his opening speech at the meeting last week, was one of the strangest, we should imagine, ever placed before a body of shareholders; and the circumstances under which it was told were strange also. The board of directors was until quite recently composed of Mr. Hugh Watt, M.P., Mr. John Brown, and Mr. Louis Swabey. Mr. Brown resigned—Mr. Watt says on account of illness. Mr. Swabey, according to the same authority, is not to be trusted, and was therefore treated like an outsider, for he was not allowed to see the directors' report until it was issued to the rest of the shareholders. Mr. George Howell, M.P., being asked by his friend the chairman, consented to lend a helping hand on the board tentatively, his friend the chairman paying, or intending to pay, his fees. Practically, therefore, it will be seen that the board now consists of Mr. Hugh Watt, for Mr. Hugh Watt's friend can scarcely have had time yet to learn the true position of the company, and Mr. Swabey has been treated as a nonentity, or as only so much of an entity as to be kept at arm's length from a knowledge of what was being done by his "colleagues." Mr. Swabey repudiates the accusations of double-dealing brought against him by Mr. Watt, and responds with an impeachment of the balance-sheet. This document shows a profit balance of £1,555; Mr. Swabey says it ought to show a loss. We do not care to be classed with that order of journalism which looks for a sensation in everything and cares for nothing which does not contain the elements of a sensation; but we confess that we shall await with a great deal of curiosity the report of the investigating committee which has been appointed. It is of no use, perhaps, to expect too much from this committee, which is avowedly friendly towards the board, but there are at least one or two men upon it who, we believe, will not scruple to drag to the

fierce light of day anything deserving condemnation which may come to their knowledge. At any rate, we may hope to hear the actual truth as to the financial position of the company.

TOWN LIGHTING.

THE prospects of great activity in the illumination of towns by electricity at an early period are exceedingly promising. Upon every side we hear of Town Councils and Local Boards interesting themselves in the electric light, making enquiries in a way that shows they are in earnest and not merely impelled by curiosity, and going to the expense of visits to and reports upon installations in towns which have already adopted the newest and best form of street lighting. Eastbourne and Brighton to some extent, Leamington and Taunton to a greater, are already lighted electrically, several other towns have resolved to follow suit, and it may be confidently assumed that a large proportion of those which at present merely have the matter under consideration will come to a similar conclusion. In our present issue we give some interesting particulars of what is contemplated—nay, decided upon—in Bradford; and we also report a discussion on the electric lighting question at a recent meeting of the Exeter Town Council which leaves little doubt in the mind as to what will shortly take place there. Here we have great pleasure in announcing that the Local Board of a town of some importance much nearer the Metropolis, Barnet to wit, has committed itself to the adoption of the electric light for the purpose of street illumination. There were several causes which made Barnet a peculiarly suitable place for the electrician to exercise, first, his powers of persuasion, and secondly (and more importantly), his technical skill. Gas is dear at Barnet—4s. 6d. per 1,000 feet; moreover, gas is bad at Barnet; naturally, therefore, the inhabitants are greatly dissatisfied with their present lighting arrangements, and were quite willing to listen to Mr. H. F. Joel when that gentleman came to them with proposals for the introduction of the electric light. Mr. Joel (whose name is well known in connection with the Pilsen-Joel Electric Light Company, with which he himself, however, has no longer any connection) first secured the interest and support of influential inhabitants of Barnet and members of the Local Board, and then went to the Board itself, which received him, if not with open arms exactly and as a deliverer, yet with much cordiality and perfect readiness to give him a fair hearing. The result of negotiations extending over a few weeks only is that the Board has passed a resolution to adopt the electric light and to give Mr. Joel the contract, together with the requisite permission to open streets and carry wires overhead so far as may be absolutely necessary. A prejudice exists in Barnet against overhead wires and it at first seemed probable that this would prove to be an obstacle to the erection of arc lamps; but Mr. Joel undertook to keep his wires as much as possible from offending the eyesight of the æsthetic people and to avoid crossing or running along the streets overhead wherever an alternative course was open. It is intended at first to erect only a few are lamps in the most conspicuous places—at the junctions of streets and spots where a broad area presents itself to be illuminated, and to leave the general street lighting to incandescent lamps of 20 C.P. Barnet is singularly compact, possessing two main streets which form the sides of a triangle, with the bulk of the town between them; thus, as a good central position has been obtained for the station, it will be comparatively easy to run the mains over the whole town. The members of the Local Board were prepared to seriously consider Mr. Joel's proposals before any price was stated, and when they anticipated that rather more than was paid for gas would be asked; they did not hesitate long before deciding that the electric light was the light for them when they learnt that he proposed to supply them at a price lower than that charged by the gas company. Gas is supplied at 4s. 6d. per thousand feet to private consumers, and at £2 18s. 6d. per lamp for street lighting; Mr. Joel will charge private consumers, if current is taken by meter, upon the basis of gas at 4s. per thousand feet, or, if consumers prefer, £2 per incandescent lamp; for the street lighting, £27 for each arc lamp and £2 14s. for each incandescent lamp. These terms are satisfactory to Barnet, inasmuch as they promise a reduction in the lighting expenses, and they are satisfactory also to the contractor for the reason that he thinks they will yield a very good profit. As far as the contracting parties are concerned, we believe, the arrangements are practically settled; there is perfect agreement between them, and the work will in all likelihood be almost at once entered upon. We have an idea that the assent of the Board of Trade is requisite to the carrying out of the undertaking, and this may involve some little delay in the completion of the work; but seeing that the local authority is in accord with the promoters of the scheme, is, in fact, itself a promoter, it is scarcely likely that any serious difficulty will arise in this connection.

We are exceedingly pleased with the manner in which the electric lighting question has been dealt with at Barnet, for it seems to us to afford an augury of what may be expected in many another town where gas is neither too good nor too cheap. We are ourselves acquainted with towns similarly situated in this respect to Barnet. One such in particular is the very compact and business-like town of Newbury, in Berkshire. Gas costs 4s. 6d. per 1,000 cubic feet there, too, and the quality is so unsatisfactory that many shopkeepers have discarded its use and returned to oil. Complaints regarding the gas, and enquiries as to the electric light, have been uttered there quite recently in our own hearing, and, knowing several residents who possess public spirit and the spirit of enterprise, we have little doubt that a successful central station lighting scheme could be carried out in that town. We recommend an early canvass of the neighbourhood by some of our go-ahead subscribers, and promise them the benefit of our acquaintance with Newbury and its inhabitants.

IT is satisfactory to find that theatrical authorities are in accord with electricians as to the importance of lighting theatres by electricity. Several managers in London have adopted the new system to some extent: others are actively bestirring themselves to get upon the safe side. Mr. W. S. Gilbert is about to build a new theatre and assume the management himself; and in the future home of the delightful Gilbertian comic opera the calm rays of the electric light will shine upon actors and audience, we hope to their common comfort, satisfaction and safety. Mr. Gilbert is thorough in his appreciation of the electric light, for he would have its adoption in theatres made compulsory by Act of Parliament. One of the uses to which electricity will be put in the new house is to light the stage by means of a row of lights lining the inside of the proscenium on both sides and across the top; this innovation will in effect, Mr. Gilbert thinks, allow the footlights to be wholly dispensed with. The *Stage* suggests electric footlights, than which it can conceive nothing better in point of comfort, artistic effect and safety. The *Stage*, which is just as much in favour of the electric light as Mr. Gilbert, says most managers who have adopted it are enamoured of it, and concludes its comments upon the Oporto Theatre fire with this remark:—"If managers desire to avert these disasters both to the public and themselves, let them isolate the stage from the auditorium, banish gas from behind the scenes, and instal electricity."

IN Madrid gas has been prohibited as far as the theatres are concerned, and the adoption of the electric light within six months from the end of March is now compulsory. In some towns of France, likewise, the electric light alone is permitted in the theatres. We have scarcely dared to hope that within any very short period it would be made compulsory in England; but, as we stated last week, information has reached us that one of the projected Bills dealing with theatres—Mr. Dixon-Hartland's, we presume—will contain a clause having that object. Notwithstanding that it is scarcely probable that this particular Bill will be dealt with in Parliament, Mr. Ritchie's measure for Local Government altering the conditions completely, we are glad that the proposal has been made, for the idea will become familiar to the public mind, and when the proposition is definitely put forward it will not come with such suddenness as to prejudice its reception.

THE Chief Justice of the United States, Morrison R. Waite, died suddenly on the morning of Friday, March 23rd. He had presided on the Bench in the Supreme Court on the Monday of the same week during the reading of the opinion of the Court in the famous Bell telephone case. This was his last appearance on the Bench. It is a remarkable coincidence that the late Master of the Rolls, Sir George Jessel, died a few days after delivering his opinion in the Bell case in 1882, having sat on the Bench for the last time to deliver that opinion.

THE Electrical Power Storage Company would be rendering a great service to the future development of electric traction if it would guarantee a life of, say, six months to a really efficient storage battery for tramcar purposes, and allow competent individuals interested in the subject to make a practical trial for the period named. Mr. Reckenzaun gave figures long ago to show that even with this limited life it would be more economical to use secondary batteries for the purpose than horses. Still it is evident that this belief is not universal, although it appears that opinions are directed more against the durability of the plates than the economy of the system. We have appealed more particularly to the above-named company as it is in a better position to attain the desired end than any other manufacturing firm with which we are acquainted.

MR. SPRAGUE'S very voluminous letter will be read with interest by the majority of our readers, but with what feelings it will be received by Messrs. Mordey, Thompson, Ayrton, Perry and Reckenzaun we cannot pretend to say. So far as we are ourselves concerned we do not at the moment offer any comments upon its contents owing to its late arrival, but doubtless Mr. Sprague has explained everything very much to his own satisfaction although some of his reasons for so long delaying his defence may be more or less matters of opinion. The gentlemen to whom our correspondent directly addresses himself are well able to take care of themselves, and Mr. Sprague will probably find his hands as full as he cares to have them.

THE combination of the dust destructor and the electric light, first proposed at Southampton, and then at Weston-super-Mare, is now exercising the minds of the councillors of Folkestone, who have been in correspondence with Mr. Bennett, the borough surveyor of Southampton, upon the subject. Mr. Bennett has given information as to the expense of laying down and working the destructor, assured the Folkestone councillors that they would get power for driving their dynamos for almost nothing, and invited them to see the destructor in operation in Southampton. If these towns make use of the destructor, not only for destroying refuse, but for supplying power for electric lighting, we shall expect to see many others following suit.

MR. A. A. CAMPBELL SWINTON points out in our correspondence columns the manner in which the reported results of lawsuits are sometimes handled for trade purposes. As our correspondent says, if the contention of the U. T. Company is upheld, all "membrane" receivers will come under the ban of its patent rights. We may safely assume that the Equitable Telephone Association will not be the only one to struggle in the toils of the monopoly net, and we shall anxiously await the further action of the keepers of the master patents.

FORTUNATELY we have so far been enabled to keep out of the Law Courts and clear from libel suits, though we have more than once felt compelled to speak very strongly with regard to schemes of a questionable character, and the individuals who promoted them. What danger we have incurred on our own part, and what danger our correspondents sometimes run us into, will be seen when Bentham's definition of libel is recalled. Said that worthy: "Anything which any man at any time for any reason chooses to be offended with is a libel."

ELECTROLYSIS OF LEAD SALTS.

By ALEXANDER WATT.

IN pursuing a series of experiments in the electrolysis of solutions of lead salts I was desirous of ascertaining, more especially, the behaviour of certain salts under the influence of the electric current, which, so far as I am aware, have received but little attention from the electro-metallurgist. Moreover, I was anxious to find out whether the spongy and crystalline character of the deposit, which so generally succeeds the first deposited layer or film when acid solutions of lead are employed as the electrolyte, could in any way be checked or prevented, and a reguline coating obtained in lieu thereof. Again, I wished to ascertain to what extent—as is the case with most other metals—the colour of the deposited metal would be affected by the nature of the electrolyte and strength of current used in the reduction. To determine these various matters a series of brass plates, 3 inches by 1 inch, each having a copper wire attached by soldering, were obtained, and these plates were well scoured with powdered bath-brick and water immediately before being immersed in the baths. A strip of sheet lead was used for the anode, and the current obtained from quart Daniell cells, the amalgamated zinc plates of which were excited by a 1-20 solution of sulphuric acid. In many instances the current from a single cell was employed, and even with this feeble current it was frequently found necessary to immerse only a very small anode surface—in some cases $\frac{1}{16}$th that of the negative electrode being sufficient to ensure a prompt deposit of the metal. In the course of the experiments I found, as I had anticipated, that the colour of the deposited metal varied considerably, ranging from a pale grey to a dark grey, nearly approaching black. Again, while in many instances the metal deposited in the form of a dull, or "dead," film, in others it was perfectly bright, and continued to retain this character for a considerable time. When this latter condition was attained, the metal was reguline in the fullest sense. Although the electro-deposition of lead is not susceptible of any very extensive application in the arts, it might, perhaps, be applied with advantage, by way of contrast, to certain kinds of ornamental brass-work, and a film of this metal would certainly look better on the hollow surfaces of cast-brass work than when such surfaces are smeared over with blacklead or plumbago. To the electro-depositor, who, as a rule, has but little time for mere experiment, it may be interesting and useful to know which of the numerous solutions of lead salts are most favourable for yielding satisfactory deposits of the metal and the conditions under which such solutions should be worked, and it is hoped that the results I am about to describe will assist in guiding him—at least, to some extent.

1. *Acetate of Lead.*—The readiness with which more or less concentrated solutions of this salt yield crystalline deposits of the metal are too well known to need further notice; I, therefore, determined to ascertain whether a more reguline condition of the metal could be obtained with weak solutions, for which purpose 50 grains of acetate of lead were dissolved in 10 ounces of water, and acetic acid then added, a few drops at a time, until the turbid solution became clear. With the current from a single Daniell cell no appreciable deposit was obtained on a clean brass plate; two cells, in series, were therefore adopted, when a semicircular film of lead slowly formed—at first on one edge of the plate only, but after a few minutes a corresponding deposit took place on the opposite edge of the plate, both films gradually, but very slowly, extending toward the centre of the plate, while no deposit whatever occurred either on the upper or lower surfaces of the cathode. In about 15 minutes from the commencement minute crystals of lead formed upon the extreme edges of the plate. It being evident that even in this weak bath a deposit could not be obtained from the acetate solution without the formation of crystals, the bath was next modified as stated below.

2. *Acetates of Lead and Soda.*—Fifty grains of acetate of soda crystals were added to the foregoing solution, and the liquid stirred until these were dissolved, when a fresh plate was immersed and a single Daniell cell only employed. The plate at once became coated all over with an uniform film of lead, but of a rather dark grey colour; in rather less than ten minutes, however, small crystals of lead formed at the edges of the plate, when it was withdrawn, and 50 grains more of acetate of soda added and dissolved as before. A fresh plate was then put into the bath, and this became very promply coated with a leaden film, but as the colour was rather dark the anode surface was diminished, when the colour assumed a lighter grey tone. Even with a very small anode surface, however, the film again became dark after a few minutes, and minute crystals formed all over the surface of the plate, and not on the edges, as before. The deposit was found to be very adherent, and even the crystals adhered more firmly to the underlying film than is usual with this form of the metal. The solution was next further diluted with water, at which point the bath contained about one grain of the lead salt and two grains of soda acetate to the ounce of liquid. A new plate having been immersed, it slowly became covered with a bright film of metal, but this soon assumed a dull opalescent appearance, and after being in the bath about ten minutes, a dark grey spongy film, somewhat crystalline at the lower edge of the plate, was obtained. The anode on being rubbed with the finger proved to be coated with a dense black powder.

3. *Tartrate of Lead.*—A solution of this salt was prepared by digesting recently-precipitated hydrate of protoxide of lead in a strong and hot solution of tartaric acid, which dissolved the oxide freely. The solution being allowed to cool, was then filtered, and the clear liquor afterwards moderately diluted with water. With the current from two Daniells a bright deposit of lead of good colour was obtained upon a brass plate, while there was no evolution of hydrogen. The film continued bright for a long time and maintained a perfectly uniform character throughout, while being firmly adherent. The anode, which kept clean, appeared to have been freely acted upon. A plate of steel was next put into the bath, which became readily coated with lead, and it was found that the film adhered very firmly to the steel surface. Being desirous to find a solution which would not only yield a good deposit of the metal, but also dissolve the anode with sufficient rapidity to keep up the metallic strength of solution, I tried the following experiment to determine the solvent action of a tartaric acid solution under the influence of the current.

4. *Tartrate of Lead by Electrolysis.*—A strong solution of tartaric acid was first prepared, in which was placed a lead anode and brass cathode, the current from two Daniell cells being employed. Soon after the respective poles had been immersed, hydrogen bubbles appeared all over the surface of the negative plate, and appeared to rest upon it with little disposition to move until the plate was shaken in the bath. These bubbles greatly retarded the action of the current, and required to be continually removed by drawing the plate out of bath every few minutes. In about half an hour or so, a bright film of lead formed on the plate, at which period it was noticed that the hydrogen bubbles ceased to be evolved at its surface. As only one half the plate had been immersed in the bath up to this time, the remaining portion of the plate was now lowered into the bath to ascertain whether the hydrogen would show only upon the brass surface and not upon the lead, and such actually proved to be the case, for while the exposed brass surface became instantly covered with bubbles of the gas, the lead coating was quite free from them. This would indicate that in electrolysing a solution of tartaric acid for the purpose referred to, the cathode should first be coated with a film of lead. Having thus determined the solubility of lead in the tartaric acid solution, by electrolysis, it became still more evident that the tartrate of lead could be employed with advantage in forming a lead-depositing bath, and,

indeed, I am disposed to give this solution the preference over most other solutions for the deposition of lead. It was noticed that there was no disposition for the metal to deposit either in the crystalline or spongy form from the tartrate solution, in which respect it has an advantage over most of the lead salts.

Plumbate of Potassa.—A quantity of peroxide of lead was digested in a concentrated and hot solution of caustic potash, which readily dissolved it, and the clear liquor, after cooling, was decanted and diluted with about eight volumes of cold water. With the current from one Daniell cell and small anode surface, a very quick and bright deposit of lead of a light grey colour was obtained upon a brass cathode. A copious and dense bright yellow insoluble powder, however, formed upon the surface of the anode. The solution was then further diluted with an equal bulk of water, when the deposition took place more gradually; but the yellow deposit on the anode formed very fast, and continued to fall off the plate and speedily settle at the bottom of the vessel. The film of metal upon the cathode was found to be non-adherent on brass, copper and steel. A strip of sheet zinc became coated with a film of lead in this solution, which was firmly adherent.

Plumbite of Potassa.—A bath was prepared by dissolving moist hydrated protoxide of lead in a moderately strong solution of caustic potash, the liquid being afterwards considerably diluted with water and allowed to settle until quite clear, when the solution was decanted for use. In electrolysing this solution, the current from one cell was employed, and it was found necessary to immerse only a very small surface of anode—about one-sixteenth of that of the cathode—to prevent the deposit from forming too rapidly. Even under these conditions, however, the deposition was very quick, a light grey film of lead being received upon the plate immediately after immersion. When a larger anode surface was immersed the deposit was of a much darker colour, and it was not until the immersed surface had been reduced to the extent above indicated that a film of good colour could be obtained. After the plate had been in the bath about half-an-hour, small dark spots appeared at the lower part, which were found to be due to the formation of spongy metal; the film also became streaky, while at the same time a white deposit of oxide formed on the face of the anode. The coating on the brass plate was found to be not very adherent; a steel plate was then substituted, upon which a film of lead rapidly formed, which adhered very firmly to the metal.

7. *Chromate of Lead in Caustic Potassa.*—A quantity of moist chromate of lead was added to a strong solution of caustic potash, in which the lead salt became readily dissolved. The solution was afterwards moderately diluted with water, and electrolysed with the current from one Daniell cell, but no deposit was obtained upon a brass cathode. Another cell was then added, in series, when the plate at once became coated with a patchy and somewhat iridescent film of lead, which was very firmly adherent. On allowing a second plate to remain in the bath for a short time the film gradually became darker, until it finally assumed a dark grey colour, while an insoluble powder formed on the anode, which fell from its surface and sank to the bottom of the vessel.

Nitrate of Lead.—A solution of this salt was formed by dissolving 50 grains of the salt in ten ounces of water. With the current from one cell, a very slight deposit of lead only could be obtained at the lower corners of the plate. With two cells a dark, patchy film was at once received upon the cathode, but the deposit was only partially metallic and non-adherent. The solution being further diluted, a somewhat better result was obtained for a moment, but the plate soon assumed the black, non-metallic aspect. The bath was next modified, as under.

Nitrates of Lead and Potassa.—To the above solution about 50 grains of nitrate of potassa were added and dissolved into the liquid with stirring. The current from one cell was used, and it was found that the bath was more active from the addition of the potash salt. Soon after immersion in the mixture, a brass plate became coated with a patchy film, portions of which were of a metallic character, while the remainder was dark coloured and apparently non-metallic. The whole of this film became readily dislodged by the finger. A further addition of water was given, but no modification produced a good deposit; after a short time a newly-prepared plate, which at first became coated with a film of bright metal in parts, became thickly coated with a spongy deposit, when the liquid was abandoned as useless.

10. *Chloride of Lead.*—A bath was prepared from this salt by dissolving finely-powdered litharge in a boiling solution of dilute hydrochloric acid, when the solution was set aside to cool and crystallise. The supernatant liquor was next poured off the crystals and electrolysed with the current from one cell, when a dark-coloured film soon formed upon a brass plate, the character of which, however, improved somewhat when the plate was kept constantly in motion. On examining the film after a few moments, and rubbing it with the finger, a bright coating of lead appeared beneath the dark film, which was firmly adherent. The solution was again diluted with water, but without much advantage, since the deposit still retained its dark brownish colour, with white metal beneath as before. The anode became covered with a white powder insoluble in the liquid.

11. *Chlorides of Lead and Potassium.*—A small quantity of chloride of potassium was added to the above solution and dissolved in the liquid, which was then tried with the current from one cell; as before, the plate received a brown-coloured film, but this, on being rubbed, exhibited a coating of metallic lead beneath. More chloride of potassium was now added, and the bath further diluted, when a comparatively white and perfectly bright film of lead slowly formed on the cathode and maintained this character for some time, and though the film eventually assumed a somewhat dull appearance, yet the depesit, on the whole, was fairly good.

12. *Chlorides of Lead and Sodium.*—A portion of the chloride of lead solution used for making up the former baths was next tried with the addition of a moderate quantity of chloride of sodium, and the liquid, as before, considerably diluted, and electrolysed with a single Daniell. As in the last case, the film slowly formed, and was perfectly bright and of good colour, retaining this character for many minutes, and exhibiting no tendency either to sponginess or crystallisation. The white deposit on the anode, which as before continually formed upon that electrode, eventually retarded the passage of the current, when the experiment was brought to a close.

13. *Borate of Lead.*—A small quantity of solution was made by boiling hydrated protoxide of lead in a strong solution of boracic acid; as only a very small amount of the lead oxide entered into the solution, the liquid was not capable of yielding any result of importance. With two cells, however, a film of lead, of a darkish grey colour, was obtained upon a copper rod, to which the deposited metal firmly adhered.

14. *Acetate of Lead by Electrolysis.*—A lead anode was immersed in a mixture composed of one part of commercial acetic acid to two parts of water, and the current from two Daniells in series passed through the liquid, when in less than two minutes crystals of lead appeared upon a brass plate, and continued to form with great rapidity until the bottom of the vessel was completely covered with them. The rapidity with which the acetic solution became impregnated with metal, under the influence of the current, was of course the only feature of interest in this experiment.

(*To be continued.*)

Sale of Steam Engines.—An important sale of new steam engines is announced to take place on the 12th at the works of Messrs. Burrows and Stewart, at Banbury, rendered necessary by the retirement of Mr. Stewart.

HARCOURT'S PENTANE STANDARD LAMP.

We have recently had occasion to draw attention to the Pentane Standard Lamp devised by Mr. A. Vernon Harcourt.

The excellent work done by this lamp has been shown by Mr. W. T. Dibdin in his report upon Standards of Light to the Metropolitan Board of Works, in which the lamp stood at the head of all the standards tested and yielded the exceedingly good average of 97 per cent. of the tests within one per cent. the mean value, a result, we take it, never before reached by any standard tested under similar conditions.

We understand that Mr. Harcourt's aim in devising this lamp was to produce a portable and self-contained instrument, dispensing with some of the more bulky apparatus employed in his well-known Pentane Standard.

Notwithstanding the excellent results attained, Mr. Harcourt believed he could construct a lamp on a somewhat different principle which would be equally exact and more easily managed. This new form of lamp he exhibited before the Physical Section of the British Association at its meeting in Manchester last year. The new lamp has been put into the hands of the makers of the former lamp, and we append a sketch of it. The new form of lamp instead of burning a mixture of air and pentane burns pentane vapour only, and though unprovided with any glass chimney round the flame, burns steadily even when exposed to moderate draughts. At the same time the important condition that the colour of the flame produced by the direct combustion of the rich pentane vapour should be as white as possible is accomplished, as will be shown by the same apparatus.

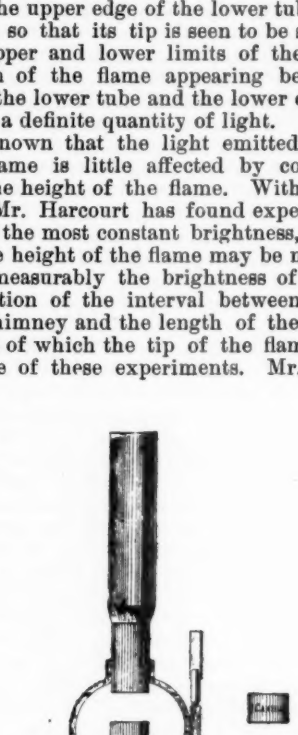
It will be seen from our sketch that the lamp takes a form somewhat similar to an ordinary spirit lamp with an additional metal chimney above. The metal chimney by producing a strong upward draught, serves a twofold purpose: (1) the flame is kept exceedingly steady, and (2) the temperature of combustion is raised and a whiter light is produced.

It will also be seen that a wick is employed, which would be a distinct disadvantage were it used as wicks generally are, within the flame or close to the point of combustion of the vapour, but in this case the wick remains at a distance of two or three inches from the point of ignition and serves only to convey the liquid pentane by capillary action to a part of the tube in which it is volatilised by the warmth conducted downwards from the flame. The wick, it will be observed, is enclosed in a tube in which it fits comfortably and which is open at the upper and lower ends. This tube is jacketed by a larger tube to which it is attached by flat plates. This jacketing serves to produce a steady temperature of the liquid vapour contained within it, the vapour burning as it is produced at the upper extremity of the tube. These two tubes are further jacketed by another larger one, the upper portion of which is contracted into a smaller tube which is of the same size as the lower portion of the chimney.

The chimney itself is enlarged in its upper portion and is attached by two metal bands to the exterior of the larger part of the lower tube. The bands are so shaped as to be at some distance from the flame and, by means of slots cut in their lower portion, the chimney of the lamp can be moved up and down within the necessary limits. The lower tube is removable and is attached to a gallery (solidly fastened to the base of the lamp) by a bayonet joint.

The action of the lamp is as follows:—On removing the lower tube and warming the inner tubes, the pentane vapour rises from the opening in the small tube and can there be lighted. On putting on again the large tube with the chimney attached, the flame rises above the top of the edge of the lower tube, and by slightly raising the wick the top of it passes into the chimney. In this chimney two narrow slots of 10 mm. high are cut diametrically opposite to each other, so that the tip of the flame may be seen through either of them. When the movable chimney is set at a definite height above the upper edge of the lower tube, and the flame is raised so that its tip is seen to be somewhere between the upper and lower limits of the slots, the central portion of the flame appearing between the upper edge of the lower tube and the lower edge of the chimney gives a definite quantity of light.

It is well known that the light emitted from the centre of a flame is little affected by considerable variations in the height of the flame. With the flame of this lamp Mr. Harcourt has found experimentally what part is of the most constant brightness, and what variation in the height of the flame may be made without affecting measurably the brightness of this part. The actual position of the interval between the lower tube and the chimney and the length of the slot opposite to any part of which the tip of the flame may be, are the outcome of these experiments. Mr. Harcourt



has found, and his results have been confirmed by subsequent experiments at the makers' factory, what portions of the flame must be selected to give a light of 1 candle or 1½ or ½ candle, as may be preferred.

Of course any intermediate values can also be obtained by setting the chimney at various heights above the lower tube and thus altering the amount of light visible between the upper and lower tubes.

The method for accurately setting the height of the chimney is both ingenious and simple, in fact it forms one of the most attractive features of the lamp. Small gauges of accurate height and exactly fitting the outside diameter of the upper and lower tubes are inserted between them; the chimney is lowered until it rests firmly and securely upon the gauge; it is then screwed tightly to the lower cylinder by means of set screws and the gauge is withdrawn horizontally, leaving, of course, a distance between the two tubes exactly equal to its height. In the case of the gauge requisite to obtain half a candle, it is found necessary to add a small collar upon the lower tube so as to ensure a por-

tion of the flame being used which will remain perfectly constant, even though the height of the flame vary within the prescribed limits. This variation of the height of the flame is found to be exceedingly small after the lamp has been alight for 10 minutes or a quarter of an hour and the inner tube has reached a constant temperature, the constancy of which temperature is greatly increased by the method of double jacketing which has been employed.

In order to make the instrument thoroughly accurate, as well as convenient, the inventor has added a base with levelling screws and a simple and efficient method of levelling the lamp, in addition to which he has provided a small piece of glass suitably fixed to reflect the upper portion of the flame visible through the slots, so that its position with regard to the slots may be verified at any time by an observer towards whom the face of the lamp is turned.

The colour of the light is such as to make photometry of ordinary gas lights exceedingly easy, in fact, it is nearly the same as that of the pentane flame, against which no such objections have ever been made on the ground of colour as have been made in the case of the well-known Amyl Acetate Lamp.

The lamp has been well tested in exposed positions, and has stood the tests remarkably well, the flame resembling a luminous pencil more nearly than an ordinary flame.

Mr. Harcourt pointed out before the Physical Section of the British Association that owing to the employment of an upper and lower cut-off it is impossible to measure distances from any portion of the flame or any point in front of it, so that the law of variation of light according to the inverse square of the distance should exactly hold; but he stated that if distances are measured from a point midway between the axis of the flame and the face of the cut-off, the errors from this cause are perfectly negligible at all distances not less than 10 inches; and he has ensured this point being easily found by making the metal bands, which unite the chimney and lower tube, of half the width of the cut-off tube, and by cutting two slots in these bands into which a metal plate can be slipped. The lamp can thus be brought into its true position either by setting the edges of the bands, when the lamp is at the right height, between two plumb lines lying in a plane perpendicular to the photometer bar and passing through its zero, or by direct measurement from the face of the metal plate.

The work done by Mr. Harcourt towards the production of a thoroughly reliable standard of light and the success which has attended his previous efforts, are sufficient guarantee that the new form of lamp will not only prove a thoroughly reliable instrument but will be found not less accurate than the previous forms invented by him; while the practical experience of the makers of the lamp and their well-known accuracy in the production of scientific instruments will ensure the lamp being so made as to bear successfully the test of everyday work.

LIGHTING THE UNION BANK OF LONDON.

This bank has been fitted throughout with the electric incandescent light by Messrs. B. Verity & Sons, under the supervision of Messrs. Drake & Gorham, who are acting as engineers on behalf of the bank. The plant, which is fixed in the basement of the premises, consists of two Otto 9 H.P. gas engines driving two Elwell-Parker latest inverted B type 12-unit dynamos running at 750 revolutions, and fitted with a flywheel, which effectually removes all fluctuation from the lights. An accumulator of 106 L 23 type cells in glass boxes is used in conjunction with the machines for supplying part of the lamps during the main lighting, and of furnishing current after the machines are stopped. Distributing switchboards, fitted with Drake and Gorham's patent ring contact switches, are used for controlling the dynamo, accumulators and lamp circuits. The wiring has been carried out with a number of small circuits so arranged that, should any failure occur to half the generating plant, every alternate lamp only will be affected. This arrangement also enables all the fuses to be placed in the engine room where they are readily accessible. The fittings have been specially designed for office work, and every desk standard contains both gas and incandescent lamps, the jets projecting at either side of the incandescent lamp and forming a support for the shade. The total number of lamps fixed is 330, most of which are half frosted either at the cap or point end to suit pendants or standards. This method of toning the brilliancy of the filament is more economical than lamps frosted completely, as only the portion of the lamp in the line of the eye is obscured, the remainder reflecting its full light to the desks. A modified pattern of the Edison screw lampholder with tap is employed throughout, and each lamp is provided with the well-known Edison pattern screw safety fuse. By means of terminal boards either dynamo can be connected to either battery, and the lighting circuits can be interchanged in a similar manner. Two of Messrs. Drake and Gorham's excess indicators are fixed in connection with the batteries to give warning when the normal rate of discharge is reached, and there is also a special arrangement of cut-out for the night service, so that in the event of an excessive number of lights being used for cleaning purposes after the offices are closed, the circuit is broken and can only be replaced when the number of lamps has been reduced to the normal. This is so arranged that it is impossible for it to be wedged out of action, though at the same time it can be switched on after it has worked. The design for the silencing arrangement in connection with the engines is found to answer admirably, and there has not been the slightest complaint from noise or vibration either from the Bank officials or others in the neighbourhood. The ventilation of the engine room is effected by means of a Blackman air propeller coupled direct to a 1 H.P. Elwell-Parker motor, the speed of which can be varied as required according to the temperature of the room.

AMERICAN NOTES.

By DAS TELEPHON.

All the famous cases were decided by the United States Supreme Court in favour of the Bell Telephone Company on the 19th inst. This decision accords with the opinions I have so often expressed in my "American Notes." In my paper, published in the Review January 6th, I wrote:—"I believe the Bell patent will be sustained by the Court." In the Review of the 2nd ult., I wrote:—"The principal question to be decided is as to the scope of Bell's fifth claim, which secures to him the exclusive use of an undulatory current for telephonic purposes. If that claim be sustained, the Bell Company will continue to have the monopoly of telephone business in the United States, unless a telephone is brought out which operates on the make-and-break system."

The cases covered by the decision are six, one of them coming from Massachusetts, one from Pennsylvania, and four from New York. In the first five cases the appellants are Amos E. Dolbear *et al.*, the Molecular Telephone Company, the Clay Commercial Telephone Company, the People's Telephone Company, and the Overland Telephone Company. In the sixth the Bell Telephone Company is the appellant, against the Molecular Telephone Company.

The Chief Justice began his opinion with a review of the question raised as to whether the Bell patent of March 7th, 1876, was for an art or process of transmitting articulate speech or merely for an apparatus by which that object could be attained. The Court is of the opinion that articulate speech is one of the "vocal or other sounds" referred to in the fifth claim of the patent. Bell discovered that speech could be transmitted by gradually changing the intensity of a continuous electric current, so as to make it correspond exactly to the changes in the density of the air caused by the sound of the voice. *This was his art.* He then devised a way in which these changes of intensity could be made and speech actually transmitted. Thus his art was put in a condition for practical use. In doing this both discovery and invention were involved, and for this his patent of 1876 was issued and must be

sustained. It is said that the claim, if given this broad construction, is virtually a claim for speech transmission by transmitting it, or, in other words, for all such doing of a thing as is provable by doing it. It is true that Bell transmitted speech by transmitting it, and that long before he did so it was believed by scientists that it could be done by means of electricity, if the electrical effect could be produced. This was the thing to be done, however, and Bell first discovered the way of doing it. The Court is, therefore, of opinion that the patent must be sustained as a patent for a process or art.

The Chief Justice then considered the alleged anticipation of Bell's discovery by Philip Reis. Reis, the Chief Justice said, discovered how to reproduce musical tones, but he did no more. He could sing through his apparatus, but he could not talk, and from the beginning to the end he has conceded this. It is not contended that Reis ever succeeded in actually transmitting speech, but only that his instrument was capable of it. It was left for Bell to discover that Reis's failures were due, not to bad workmanship in Reis's instruments, but to the principle which was adopted as the basis of what had to be done. Under such circumstances it was impossible to hold that what Reis did was an anticipation of the discovery of Bell.

In the case of Daniel Drawbaugh, of Pennsylvania, the Court reviews the copious evidence tending to show that Drawbaugh succeeded in using instruments which antedated those of Bell, but the effect of this evidence, the Court says, has been completely overcome by the conduct of Drawbaugh from the time of his visit to the Centennial in 1876, until he was put forward by the promoters of the People's Telephone Company, nearly four years afterwards, to contest the claims of Bell. He was silent so far as the general public were concerned when, if he had really done what these witnesses now think he did, he would most certainly have spoken. The news of Bell's inventions spread rapidly and at once, and it took but a few months to demonstrate to the world that he had achieved a brilliant success. If it were known at Eberly's Mills, Pa., alone that Drawbaugh had been doing the same thing for years in his shop there—it certainly would have been known all through the little village if it had actually been done—no one can believe that the public could be kept in ignorance of it until four years afterwards. To our minds, the result of the experiments made with Drawbaugh's instruments conclusively showed that they could not have done what the witnesses supposed they did, and that what they saw and heard was produced by some other means than an electric speaking telephone. We do not doubt that Drawbaugh may have conceived the idea that speech could be transmitted to a distance by means of electricity, and that he was experimenting upon that subject, but to hold that he had discovered the art of doing it before Bell did would be to construe testimony without regard to the ordinary laws that govern human conduct. It is decided, therefore, that the Drawbaugh defence has not been made out.

The Chief Justice then took up the allegations of collusion and fraud made in the charge that Bell's application as originally filed in the Patent Office did not contain his present fourth claim, or any description of his variable resistance method, and that all which now appears in the specification on that subject, including the fourth claim, was surreptitiously interpolated afterwards. As to these charges the Court says:—"The cause of these differences has been explained in the most satisfactory manner, and we entertain no doubt whatever that the specification, as now found in the patent, is precisely the same as that on which the order to issue the patent was made. Not a shadow of suspicion can rest on anyone growing out of the misprint of the specification in the Dowd case."

The Chief Justice then reviewed briefly the case of the Bell Telephone Company against the Molecular Telephone Company, which involves one of the claims of the patent issued to Bell on the 30th of January, 1877. The Court below held that the fifth claim of this patent was anticipated by the Schellen magnet. Bell's patent, the Court holds, was not for the magnet, but for the telephone, of which it formed only a part. To that extent the decree in that case was erroneous. It follows that the decree in each of the cases so far as it is in favour of the Bell Company and those claiming under it must be affirmed, and that the decree in the Molecular case, so far as it is against the company on the full claim of the patent of January 30th, 1877, must be reversed and a decree directed to that extent in its favour. It is accordingly so ordered.

A dissenting opinion of Justices Harlan, Field, and Bradley was read by Justice Bradley, sustaining the claims of Drawbaugh to priority of invention.

On receipt in Boston of the news from Washington that the Supreme Court had decided in favour of all the claims in Bell's famous patents of March 7th, 1876, and January 30th, 1877, the company's stock advanced from $244 to $260, par being $100. There is a wide-spread disappointment at this decision. There has been a hope that Bell's fifth claim would be confined to the use of the undulatory current generated as described, particularly in Bell's patent, and exhibited in what is generally known as Bell's main, that is by the vibration of a metallic plate before an electro-magnet, and that the use of the microphone was not an infringment of the patent.

The Court decided that Bell's specifications named several other ways of producing undulatory currents, and that as Bell was the inventor of the undulatory current for telephony, he was entitled by his patent to the exclusive use of that current without regard to the means used to generate it. I saw your former correspondent, Mr. Barney, sitting just under the judge's bench, intent upon every word of the opinion, and occasionally bowing his head as if in approval of the points decided. I accosted him after the Court, and expressed my surprise that he should be in favour of the Bell patent after his persistent attacks upon it in the columns of this REVIEW. His answer was that the Bell patent in the United States was a totally different thing from that in England; in the latter there was not a claim for the undulatory current, whereas in the former that was the vital claim, and he referred me to the REVIEW for his opinions on the fifth claim of the U. S. Bell patents, which is for the use of the undulatory current in a telephone.

I find in the REVIEW of October 14th, 1887, the following remarks in a letter signed W. C. Barney: "I attended daily the trial of the Bell case by the U. S. Supreme Court in January, 1887, and from the arguments of counsel on both sides, and from the evidence filed in the lower courts, I do not hesitate to express my strong belief that the fifth claim will be sustained."

A very great compliment has been paid to your excellent REVIEW by the Principal Examiner of Electricity of the Patent Office since 1882, by having selected it alone from the Patent Office library to be deposited in his room instead of in the library. It is sincerely to be desired that they may have sufficient intelligence to imbibe more information about matters electrical from its pages.

Washington, *March 24th*, 1888.

GILBERT'S ARM SETTER.

THE usual method of setting pole arms at right angles to the wires is by the rule of thumb, *i.e.*, by simply relying upon the eye, but as this is a very unsatisfactory and tedious method, the little device shown will be a boon to telegraph constructors.

The instrument is driven into the side of the pole about five feet from the ground and set parallel to the

FIG. 1.

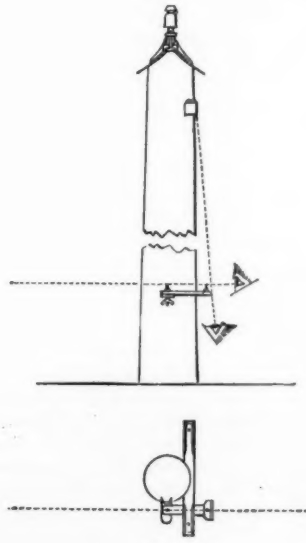


FIG. 2.

arms, fig. 1, after which a sight is taken in both directions, and the pole turned so that the sight will be equidistant at each pole in advance, fig. 2.

The importance of the arms being accurately set at right angles to the strain of the wires in all positions will be obvious, and as it is almost impossible to do so by the naked eye, this little device of Mr. Gilbert's will no doubt be welcome to many engineers. The instrument is only 9 inches by 4 inches, and can be carried in the pocket.

Konigsberg and the Electric Light.—The British Consul at Konigsberg announces that the municipal authorities of that town are advertising for tenders for the construction and maintenance of the necessary works for lighting the streets with the electric light. A copy of the conditions, with a plan of the city, can be obtained from the chief cashier of the municipality on payment of two and a half marks, and tenders will be received until April 16th.

KIRCHOFF'S LAWS AND THEIR APPLICATION.

By E. C. RIMINGTON.

(*Continued from page* 342.)

Method of obtaining the resistance between any two points of a network.*

Suppose any network containing no E.M.Fs. to consist of n meshes, and it is required to find the resistance between two points, P and Q, in it; let P and Q be joined by a conductor of resistance, ρ, containing an E.M.F., e; this will form an additional mesh whose cyclic symbol may be called x.

Now $x = \frac{e\,\Delta_n}{\Delta_{n+1}}$ where Δ_{n+1} is a determinant of the $(n+1)$th order, whose constituents are formed of the resistances of the network including the resistance ρ, and Δ_n a determinant of the nth order, formed from Δ_{n+1} by striking out one row and one column, the former being the row formed from the coefficients of the equation for the x cycle, and the latter the column formed of the coefficients of x.

Again $x = \frac{e}{\rho + R}$; where R is the resistance of the network between the points P and Q.

Hence

$$\rho + R = \frac{\Delta_{n+1}}{\Delta_n}$$

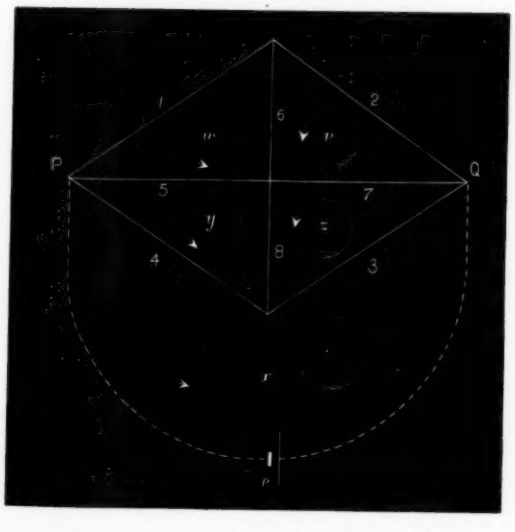
Now the value of R is obviously independent of the value of ρ, which may therefore have any value; let it equal zero

Then

$$R = \left[\frac{\Delta_{n+1}}{\Delta_n}\right]\rho = 0$$

$$= \frac{\delta_{n+1}}{\delta_n}$$

where δ_{n+1} and δ_n represent the values which Δ_{n+1} and Δ_n assume respectively when $\rho = 0$: or δ_{n+1} reprerents the determinant formed of the coefficients of the cyclic symbols from the different equations when the resistance of the branch containing the E.M.F. is zero, the first column being formed of the coefficients of the



cyclic symbol of the mesh containing the E.M.F., and the first row of the coefficients of the cyclic symbols in the equation to the same mesh; δ_n is the determinant derived from the above by excising the first row and the first column.

* This method is due to Dr. Fleming and is contained in the paper by him, which was referred to on page 226.

As an example, let us take the network given on page 226. Join P and Q by a conductor of no resistance containing the E.M.F., e.

We have the equations

$$\begin{aligned}
(r_3 + r_4)\,x - r_4\,y - r_3\,z - 0\,v - 0\,w &= e\\
-r_4\,x + (r_4 + r_5 + r_8)\,y - r_8\,z - 0\,v - r_5\,w &= 0\\
-r_3\,x - r_8\,y + (r_3 + r_7 + r_8)\,z - r_7\,v - 0\,w &= 0\\
-0\,x - 0\,y - r_7\,z + (r_2 + r_6 + r_7)\,v - r_6\,w &= 0\\
-0\,x - r_5\,y - 0\,z - r_6\,v + (r_1 + r_5 + r_6)\,w &= 0
\end{aligned}$$

$$x = \frac{\begin{vmatrix} e & -r_4 & -r_3 & 0 & 0\\ 0 & \overline{r_4 + r_5 + r_8} & -r_8 & 0 & -r_5\\ 0 & -r_8 & \overline{r_3 + r_7 + r_8} & -r_7 & 0\\ 0 & 0 & -r_7 & \overline{r_2 + r_6 + r_7} & -r_6\\ 0 & -r_5 & 0 & -r_6 & \overline{r_1 + r_5 + r_6} \end{vmatrix}}{\begin{vmatrix} \overline{r_3 + r_4} & -r_4 & -r_3 & 0 & 0\\ -r_4 & \overline{r_4 + r_5 + r_8} & -r_8 & 0 & -r_5\\ -r_3 & -r_8 & \overline{r_3 + r_7 + r_8} & -r_7 & 0\\ 0 & 0 & -r_7 & \overline{r_2 + r_6 + r_7} & -r_6\\ 0 & -r_5 & 0 & -r_6 & \overline{r_1 + r_5 + r_6} \end{vmatrix}} = \frac{e}{R}$$

Hence

$$R = \frac{\begin{vmatrix} \overline{r_3 + r_4} & -r_4 & -r_3 & 0 & 0\\ -r_4 & \overline{r_4 + r_5 + r_8} & -r_8 & 0 & -r_5\\ -r_3 & -r_8 & \overline{r_3 + r_7 + r_8} & -r_7 & 0\\ 0 & 0 & -r_7 & \overline{r_2 + r_6 + r_7} & -r_6\\ 0 & -r_5 & 0 & -r_6 & \overline{r_1 + r_5 + r_6} \end{vmatrix}}{\begin{vmatrix} \overline{r_4 + r_5 + r_8} & -r_8 & 0 & -r_5\\ -r_8 & \overline{r_3 + r_7 + r_8} & -r_7 & 0\\ 0 & -r_7 & \overline{r_2 + r_6 + r_7} & -r_6\\ -r_5 & 0 & -r_6 & \overline{r_1 + r_5 + r_6} \end{vmatrix}}$$

It will be noticed that in the numerator determinant the dexter diagonal is found by writing the sum of the resistances bounding each mesh commencing with the one containing the E.M.F., and the constituent at the point of intersection of any row and column is the resistance separating the two meshes, whose bounding resistances occur respectively in the row and column, with the minus sign prefixed; if the two meshes are non-adjacent the constituent common to the row and column containing them is zero. If x, y, z, v and w represent the meshes, ΣR_x, ΣR_y, &c., the sum of the resistances bounding them respectively, and R_{xy} the resistance separating the mesh x from the mesh y.

Then joint resistance

$$= \frac{\begin{vmatrix} \Sigma R_x & -R_{yx} & -R_{zx} & -R_{vx} & -R_{wx}\\ -R_{xy} & \Sigma R_y & -R_{zy} & -R_{vy} & -R_{wy}\\ -R_{xz} & -R_{yz} & \Sigma R_z & -R_{vz} & -R_{wz}\\ -R_{xv} & -R_{yv} & -R_{zv} & \Sigma R_v & -R_{wv}\\ -R_{xw} & -R_{yw} & -R_{zw} & -R_{vw} & \Sigma R_w \end{vmatrix}}{\begin{vmatrix} \Sigma R_y & -R_{zy} & -R_{vy} & -R_{wy}\\ -R_{yz} & \Sigma R_z & -R_{vz} & -R_{wz}\\ -R_{yv} & -R_{zv} & \Sigma R_v & -R_{wv}\\ -R_{yw} & -R_{zw} & -R_{vw} & \Sigma R_w \end{vmatrix}}$$

Obviously, $R_{yx} = R_{xy}$, $R_{vz} = R_{zv}$ and so on, consequently it will be seen that the numerator determinant is symmetrical about its dexter diagonal.

We thus have the following rule for finding the joint resistance of any network between any two points :—"Join the points between which the resistance is required by an additional conductor of zero resistance, calling the mesh thus formed the *added* mesh ; for the numerator of the joint resistance write down a determinant, whose dexter diagonal is formed of the sum of the resistances bounding each mesh, commencing with the added mesh, and whose other constituents are formed on the principle that the constituent common to any row and column is the resistance separating the two meshes, whose bounding resistances occur in the row and column respectively, a minus sign being prefixed to this resistance ; when the two meshes are non-adjacent the constituent common to the row and column containing their bounding resistances is zero. The denominator is formed from the numerator by striking out the first row and the first column."

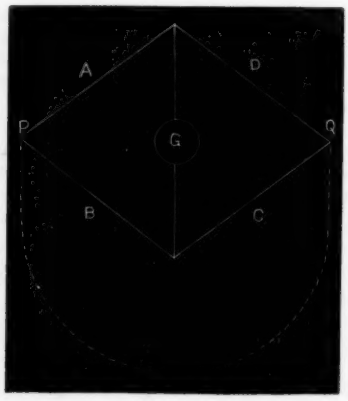
As the numerator determinant is symmetrical about the dexter diagonal, it will suffice to write down the half on one side of the latter by means of the above rule, the other half can then be written by imagining the forming half reflected in the diagonal, as if it were a mirror.

To find the joint resistance of a Wheatstone bridge.

$$R = \frac{\begin{vmatrix} \overline{B+C} & -B & -C \\ -B & \overline{A+B+G} & -G \\ -C & -G & \overline{C+D+G} \end{vmatrix}}{\begin{vmatrix} \overline{A+B+G} & -G \\ -G & \overline{C+D+G} \end{vmatrix}}$$

$$= \frac{G(A+D)(B+C) + AB(C+D) + CD(A+B)}{G(A+B+C+D) + (A+B)(C+D)}.$$

That this is correct is easily shown, for suppose G to be infinite, then the resistance between P and Q is the joint resistance of A + D and B + C.



The value of R may be written

$$\frac{(A+D)(B+C) + \dfrac{AB(C+D) + CD(A+B)}{G}}{A+B+C+D + \dfrac{(A+B)(C+D)}{G}}.$$

If $G = \infty$ this becomes

$$R = \frac{(A+D)(B+C)}{(A+D)+(B+C)}$$

which is the joint resistance of A + D and B + C.

Again, if G equals zero, the resistance is the joint resistance of A and B plus that of C and D.

When G = 0

$$R = \frac{AB(C+D) + CD(A+B)}{(A+B)\ (C+D)}$$

$$= \frac{AB}{A+B} + \frac{CD}{C+D}$$

Again, when there is a balance, A C = B D. or $A = \frac{B\,D}{C}$, substituting this value for A in the equation for R, we have

$$R = \frac{GD(B+C)^2 + BD(C+D)(B+C)}{G(B+C)(C+D) + B(C+D)^2}$$

$$= \frac{D(B+C)\{G(B+C) + B(C+D)\}}{(C+D)\{G(B+C) + B(C+D)\}}$$

$$= \frac{D(B+C)}{C+D}$$

R also equals $\dfrac{B(A+D)}{A+B}$

since A C = B D.

Hence by addition

$$R = \frac{B(A+D) + D(B+C)}{(A+B) + (C+D)} = \frac{AB+BD+BD+CD}{A+B+C+D}$$

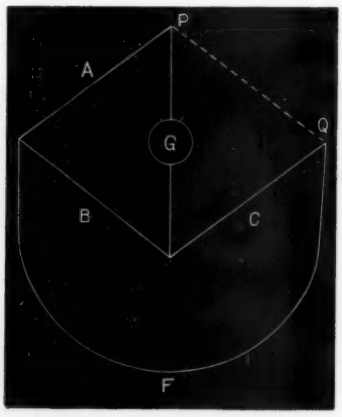
$$= \frac{AB + AC + BD + CD}{A+B+C+D}$$

$$= \frac{(A+D)(B+C)}{(A+D)+(B+C)}$$

which is the same result as was obtained when G equalled infinity. This might have been deduced at once from Bosscha's first corollary since, when there is a balance, the current through G is zero, and its resistance may have any value.

Suppose that in Mance's internal resistance test it is required to find the external resistance through which the battery is circuited.

The resistance between P and Q is, from an inspection of the diagram, seen to be of the same form as the



resistance of the bridge, the conductors, B and G, being interchanged, and F taking the place of D. Therefore

$$R = \frac{B(A+F)(G+C) + AG(C+F) + CF(A+G)}{B(A+G+C+F) + (A+G)(C+F)}$$

This may be written

$$R = \frac{F\{G(A+B+C) + C(A+B)\} + GA(B+C) + ABC}{F(A+B+G) + G(B+C) + C(A+B) + AB}$$

If $F = \infty$

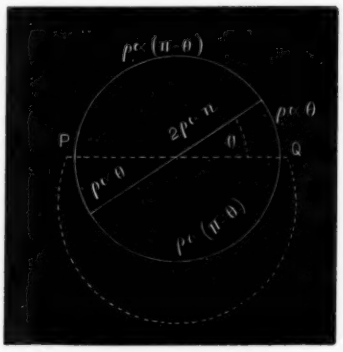
$$R = \frac{G(A+B+C) + C(A+B)}{A+B+G}$$

If $F = 0$

$$R = \frac{G\,A\,(B+C) + A\,B\,C}{G\,(B+C) + C\,(A+B) + A\,B} = \frac{A\,\{G\,(B+C) + B\,C\}}{(A+G)\,(B+C) + B\,C}$$

These two latter results may of course be obtained by means of the ordinary laws of shunts.

As a final example, consider the case of a circular conductor of uniform resistance bridged across by a straight conductor, which forms a diameter. Let the resistance be required between two diametrically opposite points, P and Q, the straight conductor making



some angle, θ, with the line joining P and Q. Let a be the radius, ρ the resistance per unit of length of the circular conductor, and $n\,\rho$ that of the straight conductor per unit of length.

Then we have

$$R = \begin{vmatrix} \rho a \pi & -\rho a(\pi-\theta) & -\rho a \theta \\ -\rho a(\pi-\theta) & \rho a \pi + 2\rho a n & -2\rho a n \\ -\rho a \theta & -2\rho a n & \rho a \pi + 2\rho a n \end{vmatrix} \Big/ \begin{vmatrix} \rho a \pi + 2\rho a n & -2\rho a n \\ -2\rho a n & \rho a \pi + 2\rho a n \end{vmatrix}$$

$$R = \rho a \cdot \frac{\begin{vmatrix} \pi & -(\pi-\theta) & -\theta \\ -(\pi-\theta) & \pi + 2n & -2n \\ -\theta & -2n & \pi + 2n \end{vmatrix}}{\begin{vmatrix} \pi + 2n & -2n \\ -2n & \pi + 2n \end{vmatrix}}$$

Now

$$\begin{vmatrix} \pi & -\pi+\theta & -\theta \\ -\pi+\theta & \pi+2n & -2n \\ -\theta & -2n & \pi+2n \end{vmatrix} = \begin{vmatrix} \pi & -\pi+\theta & -\theta \\ -\pi & \pi & \pi \\ -\theta & -2n & \pi+2n \end{vmatrix}$$

$$= \begin{vmatrix} 0 & -2n-\theta & \theta \\ 0 & -\pi-4n & -\pi+2\theta \\ \pi & \pi+2n & -\theta \end{vmatrix} = \pi \begin{vmatrix} -2n-\theta & \theta \\ -\pi-4n & -\pi+2\theta \end{vmatrix}$$

$$= \pi \begin{vmatrix} -2n-\theta & \theta \\ 2\theta-\pi & -\pi \end{vmatrix} = \pi \begin{vmatrix} -2n & \theta \\ 2\theta-2\pi & -\pi \end{vmatrix}$$

$$= \pi\,(2n\pi + 2\pi\theta - 2\theta^2) = 2\pi\,(n\pi + \pi\theta - \theta^2)$$

Also

$$\begin{vmatrix} \pi+2n & -2n \\ -2n & \pi+2n \end{vmatrix} = \begin{vmatrix} \pi & -2n \\ \pi & \pi+2n \end{vmatrix} = \begin{vmatrix} \pi & -2n \\ 0 & \pi+4n \end{vmatrix}$$

$$= \pi\,(\pi + 4n)$$

Hence

$$R = \frac{2\rho a \pi\,(n\pi + \pi\theta - \theta^2)}{\pi\,(\pi + 4n)} = \frac{2\rho a\,\{\pi\,(n+\theta) - \theta^2\}}{\pi + 4n}$$

If r be the resistance of the straight conductor $r = 2\,a\,\rho\,n$, or $n = \dfrac{r}{2\,a\,\rho}$.

Hence

$$R = \rho a \cdot \frac{\pi r + 2\rho a \theta\,(\pi - \theta)}{2r + \pi\rho a}.$$

If $\theta = 0°$

$$R = \rho a \frac{\pi r}{2r + \pi\rho a} = \frac{\frac{\pi\rho a}{2} \cdot r}{\frac{\pi\rho a}{2} + r};$$

that is, R equals the joint resistance of the two halves of the circular conductor and the straight conductor in parallel, as will obviously be the case.

If $\theta = \dfrac{\pi}{2}$

$$R = \rho a \cdot \frac{\pi r + \frac{\pi^2 \rho a}{2}}{2r + \pi\rho a} = \frac{\pi\rho a}{2}$$

which is the joint resistance of the two halves of the ring in parallel.

(*To be continued.*)

THE UNDERGROUNDING OF ELECTRIC ARC LIGHT WIRES.*

By WELLS W. LEGGETT.

THIS topic is one of absorbing interest at the present time. Municipal and legislative authority seeks to compel the burying of all the wires without discrimination, and to cast upon the parties interested the burden of finding a practical means to accomplish the end.

The progress of invention in science and art records, infallibly, the contemporaneous public demand. This demand discloses a necessity, and inventive ingenuity suggests the remedy.

Starting from this standpoint we find public wiring began with the telegraph.

At this stage, however, the interesting experiment to which the world lent a helping hand developed signs of commercial utility and value. Man's cupidity and selfishness at once antagonises what he cannot share, and we find the public arrayed in opposition to the use of the highways. Inventive ingenuity came to the rescue, and in 1816 Ronalds erected and used a telegraph in which some of his wires were placed on poles and *some were buried in the ground*. Tribavillet followed in 1828 with a system employing underground wires, and when Prof. Morse, in 1832, brought out his system, he proposed connecting Washington with Baltimore, a distance of 44 miles. To his mind the wire should be insulated and laid in a lead tube in the ground. He constructed his line with great care and at large expense; but only a few miles had been laid when the gradual escape from his line proved his scheme impracticable. He was about to abandon the undertaking when one of his coadjutors, Dr. Page, of the Patent Office, or Professor Henry, of the Smithsonian Institute, said to him: "Take your wire from the ground and train it on poles." The advice was followed and success achieved.

Here, then, in the incipiency of public wiring is the first recorded failure coupled with its remedy: "Take the wires from the ground and put them on poles."

With underground telegraph and telephone wires the electrical difficulties to overcome are much the same. Moisture must be excluded from the wires. Insulation must be good and induction be reduced to the minimum, especially between adjacent lines. In both, however, leakage from the lines due to imperfect insulation may be compensated within limits by additional battery force. The battery acts like a pump sending water through a leaky pipe, the water may all escape before reaching the discharge end—but with a more powerful pump, while increase of pressure will cause greater escape through leakage, one may succeed in discharging a limited quantity through the end of the pipe and so accomplish the purpose sought.

For this reason underground telegraph and telephone wires may be operated with a measure of success.

In most of our cities all telegraph wires might be led to a cer

* Read before the American National Electric Light Association, Pittsburgh, February, 1888.

tain point from which the wires of all systems could by one underground conduit be led to a central station or stations, and thence back through the same conduit; and where the wires are numerous might warrant the expense.

With telephone companies whose subscribers are in all parts of the city, the requirements that each wire should be conveyed underground would involve an outlay for conduits wholly prohibitive.

For direct service incandescent lighting the required conductors are so large that to train them upon poles or to train an equivalent capacity—in smaller wires on poles—would involve outlay and annoyance exceeding that required to underground the conductors.

So again the resistance of the conductors to the flow of the current is exceedingly slight; it might be compared to the pouring of water from a pitcher through a 6-inch pipe—its course of least resistance lies right forward through the pipe, and there is little tendency for it to seek an exit through any other restricted channel.

In comparison with it the arc light current might be likened to a large hose with a small nozzle through which water is being forced with a powerful pump—the tension is very great, and if so much as a pin-hole exists in the hose water will squirt therefrom, and quickly enlarge the orifice to a fatal rent.

From the fact, therefore, that telegraph and telephone and incandescent electric light wires may be trained underground with success, by no means does it follow that the same is true of arc light wires.

It is an undoubted fact that to successfully underground electric arc light wires involves simply and solely a question of expense. But expense may be of the very essence of the inquiry, for if the expense is out of proportion to the revenue that can be derived from the service, expense alone prohibits the outlay and determines it to be impracticable. Expenditure of money is alone required to tunnel the Dover Straits, and yet French and English capitalists have pronounced it wholly impracticable, as the returns could not warrant the investment. So it is with electric arc light wires; an efficient system, so far as inventive ingenuity has yet presented any plan, involves an expenditure wholly prohibitive, and for that reason alone is impracticable.

Electric arc lights may be employed successfully trained in the air on poles, and an underground system is practicable which can reproduce the same conditions. Let us examine these conditions. All substances are conductors, as copper, iron, lead, rubber, glass, dry air. Some substances are such poor conductors that, in comparison with those that are better, we call them non-conductors, and the greatest available non-conductor is dry air. We use these poor or non-conductors, such as rubber, glass, paraffin, wood, and dry air as insulators, and we find dry air to be our most perfect insulator. Dry air is a better insulator than rubber; if, therefore, in dry air two rubber-covered wires cross in close proximity to each other, the induction is greater between them than would be the case if both wires were bare. But air is usually laden with moisture and water, charged as it is with the mineral salts and acids of the atmosphere, is a good conductor. We therefore coat our line wires with an insulating material to shield them from direct contact with moist surfaces or other good conductors, and so reduce in amount the current which is always escaping by connection to the ground, and which varies in direct proportion to the conducting property of the intermediate medium.

Where our insulated wires are trained on poles we have, at the rate of 30 poles to the mile, 30 points at which a small amount of current may and always does leak off to the ground.

Now let us put an insulated cable in a conduit in the ground. The conditions are all changed in the most aggravating manner. Instead of comparatively dry air, the air is clammy and heavily laden with moisture, instead of a mass of surrounding air as on the poles, the envelop of air is, at best, but an inch more or less in thickness. Instead of resting at 30 points in a mile on glass supports, connected to dry non-conducting wooden poles to make the passage to the ground as much obstructed as possible, the line touches the conduit at, say, two or three points in the space of every foot, or at, say, 10,000 points in a mile, and the conduit itself, a much better conductor than glass or dry wood, is all that separates it from the moist earth.

The bearings at which the current may leak away have been multiplied from 30 contacts to 10,000 contacts per mile, while the conductivity of the medium at each point has been greatly enhanced. A regulating arched subway has been suggested, and approaches most nearly to a successful plan, but only a state or city could stand the necessary outlay. A subway of this character, 4 feet wide and 8 feet high for Chestnut Street alone, in Philadelphia, was estimated would cost the city $1,500,000. After completion such a subway would have to be supplied with forced ventilation to keep it dry. If, then, the insulated wires could be supported so as to touch at but 30 points to the mile, the conditions of exterior wire training on poles would be fairly approximated.

The question is frequently asked, if telephone and telegraph wires can be undergrounded, why cannot arc wires? The reason is plain, leakage or escape can be supplied in the former by additional battery power, but an arc light generator is a queer specimen of mechanics.

It starts a mild current, and this passing back around its field magnets, builds them up; the increased magnetism induces greater impulses in the bobbins of the armature; the current thus increased continues to pass through the line and back around the field magnets until the current has reached its maximum. It is, therefore, apparent that anything which leaks the current from the line not only steals the quantity which has escaped, but prevents just so much current from passing back around the field magnets, and to that extent robs the machine of its capacity to generate a current. These machines are capable of taking care of the same amount of loss at the insulators in the pole and line system; but when this is multiplied many times, as in an underground conduit, it is so robbed of its power to recuperate that the resulting lights are necessarily reduced in number, and are weakly and sickly.

Operations looking to the undergrounding of arc light wires have been prosecuted on a large scale at New York, Brooklyn, Chicago, Philadelphia, and Washington.

Notwithstanding all reports to the contrary, I find that at New York, although the subway commission has expended vast sums of money, and has succeeded in burying certain telephone and telegraph wires, no arc light line has up to this time been buried in New York city, and this is fully corroborated by the report of the board of electrical control of January 6th, 1888.

At Brooklyn, New York, the board of commissioners of electrical subways instituted thorough investigation of this subject in 1886, and in its report of December 30th, 1886, says:—

"With regard to electric light conductors this board has found no device which would, with certainty in its opinion, enable the wires carrying arc light currents to be safely and successfully operated in the same conduit with telephone and telegraph conductors without disturbance or injury to the latter.

"But the board desires to say, emphatically, that those fluent critics who talk of putting electric light conductors underground, making no distinctions between arc lights and incandescent lights, or between the arc lights of different systems, are ignorant of the alphabet of the subject."

The president of the board visited all the principal cities in Great Britain and Europe; he found no arc light wires underground, and, although a few years since such wires were trained in the Paris sewers, they have been removed, and no arc light wires are now allowed therein.

The Brooklyn Commission made another report, December 15th, 1887, and on this topic say:—

"As was fully explained in the last report, the subject of underground conduits for arc currents is the one which presents the most numerous and novel difficulties.

"Since it has been impossible for Brooklyn to take the lead in the experimental solution of these, the only remaining course was to watch carefully the progress of experiments in other cities. This has been done, both by correspondence and by personal visits of members of the board. The principal cities in which experiments of this kind have been in progress are New York, Chicago, Philadelphia, Baltimore, and Washington. In one or another of these, several systems which were regarded with favour a year ago, have since developed defects or even come to entire failure. It cannot be said that any system has yet been completely proven to be permanently satisfactory.

"There are one or two, however, which promise well, and this board awaits with attentive interest their further trial, regretting only its inability, through the cause already specified, to co-operate in the experimental investigation of the different and delicate questions involved."

There are no arc light wires underground up to this time in Brooklyn.

At Washington, in 1884, cables were laid in F street, from 9th to 15th. In a few months it was necessary to dig up a few of the same. Later there was much more trouble, and it was all taken up and relaid. About one year after the first laying it was wholly abandoned, because they could not make it work.

In 1885 they laid cables on Pennsylvania Avenue, from Ninth to First Streets, and imported an expert from Antwerp to lay them.

Twelve cables were laid in solid cement, and no expense spared to insure success. They proved an utter failure. The avenue was dug up many times. The wires were in September, 1887, mostly out of service, and the remainder were in such bad shape that they would require constant repairing or have to be abandoned.

An officer of the Washington Company writes to me under date of September 12th, 1887: "We have many committees coming here to see what we have accomplished, as they have heard that we have met with great success and so forth. We will say to you that our experience, after the outlay of many thousand dollars, is this: have nothing to do with underground cables for arc lighting if you can possibly avoid it. Many will tell you that it is perfectly practicable; look out for such parties; they are probably interested directly or indirectly in cables. There is a big lobby in that branch of business. There is no city or town in the world where a cable has been made to work two years that has been subjected to 2,000 volts of pressure.

This Washingtom Company is using lead covered cables with success for incandescent work; but as to the undergrounding of arc light wires, confirmed as late as February 7th, 1888, they report that out of 14 miles of arc light cable in 14 different circuits, all have proved total failures, and have been abandoned except a very small amount.

At Philadelphia elaborate experiments have been prosecuted. All kinds of cables have been employed, and a great variety of conduits; great trouble has been experienced. The systems largely employed were such having ducts through which the cables were drawn—in most cases the insulating compound rapidly deteriorated and became useless—in others it would be rotted and become water soaked. Where lead covered cables were used in conduits

where creosote was employed, the effect was to rapidly oxidise the lead covering and disintegrate the same. It was found that gas could not be kept from the ducts, although apparently gas tight—many explosions followed. Recourse was then had to ventilation by lamp-posts, but the trouble was not corrected. After several explosions in one system, in which persons and property were injured, a powerful fan was adjusted to force air through the conduit, deeming it better to do so than to draw the air through, which might simultaneously draw in gas. When shortly afterwards the lighting company was congratulating itself that it had overcome the difficulty, a tremendous explosion ensued, extending for a long distance, ripped up the street, and broke a large plate-glass window. That entire system of lights had to be abandoned. It was some six months ago determined by the manager that as a result of experience, no conduit would suffice for arc light wires in which there were open ducts, and that success lay in the employment of lead-covered cables buried solid. This plan, suggested by the city electricians, was tried, and success seemed assured, but they now report the experiment unsuccessful. The section buried is not great, but three bad grounds have recently developed. Two were repaired, but the third necessitated the temporary cutting out of a part of the line and the training of wires on poles, until the earth may thaw and enable access to be had to the wires.

The various companies of Philadelphia are at a loss what to try next. At this point I would note that these demands for a system for arc light wires have greatly stimulated inventive ingenuity, but as yet without success.

Out of 72 patents that have been issued in this line 53 of them have eminated from Philadelphia, New York, Boston, Brooklyn, Wilmington, Camden and Washington, all being in the immediate vicinity of the places where the operations were being conducted. The others were mostly from the general vicinity of Chicago.

Now as to Chicago—much has been said of its system—a visit to Chicago satisfied me that its electric arc light industry was being strangled. A few blocks in the immediate heart of the city were using electric light very lavishly, but the area lighted is scarcely a half mile square. This small area is served from no less than nine separate plants, formerly belonging to as many companies, but now consolidated into one.

A letter under date of September 20th, from an officer of the Consolidated Company, explains the situation there. He says:

"We have had an enormous amount of trouble with our underground arc light circuits, averaging, I would say, for the last three months, one burn out every day. The expense of reconstruction and the losses in rebates have been enormous, and the annoyance to our customers more damaging still. Commencing in April last, we bought out some nine arc light plants in Chicago, and have proceeded to concentrate them into four main stations, burning about 1,100 lights; their owners had all been using underground conductors composed for the most part of okonite, kerite, Callender and underwriters' wire. Everyone of these insulators has failed constantly, the only thing that has held up at all is lead covered cable, and we have been driven to the great expense of taking out every foot of the old construction and substitute new lead covered cables throughout. This work is not yet done. Our people are confident that a large business awaits us here, but its development will depend entirely upon service. These lead circuits may fail much sooner than is anticipated, and it is almost certain that we shall be compelled to reduce the number of lights upon a circuit—a very difficult matter in a city like Chicago. Our conduit space is already filled along the main routes, and additional conduits will be necessary. The constant tearing up of the pavements for all kinds of purposes, makes our street department very unwilling to grant permits for laying additional conduits, and several times they have been refused altogether. I would say here, that arc light business in Chicago has developed entirely since the passage of the underground ordinance of 1881—the result has been the multiplication of small isolated plants and the formation of the nine small central station plants bought out by this company. None of these plants made any money. It was impossible for them to do so, operating underground and upon so small a scale. No streets have ever been lighted by electricity here, in fact the whole industry is in a very backward condition, and is likely to remain so, except in the most densely crowded portion of the city, unless some arrangement can be made with the city authorities for overhead wires. The city is trying an experiment of its own in lighting Chicago river, which will, I am confident, demonstrate the truth of the foregoing statement; and in the course of a year I hope that our city fathers will permit overhead lines, in many places where public convenience demands electric lights while underground construction would forbid it."

At Milwaukee, Wisconsin, three systems have been tried and abandoned—*i.e.*, a wooden truck plan, and tarred iron pipe and grooved wood. A fourth consisting of tile conduits with a heavily insulated but not lead covered cable had recently been introduced and is now being tested. The company doubts whether it will stand the trying spring season.

At Detroit, the Thomson-Houston Co. employed a cable of the most expensive and approved character in the Dorsett conduit, and the mechanical work was of the best quality.

While the cable was new the results were fair, though loss by leakage rendered it impossible to produce normal lights.

It was found impossible to operate telephone wires in the same or adjacent pipes. The company soon abandoned the system, and when its cable was removed it was found the insulation had so rotted or softened that considerable lengths of the wire in many places was stripped bare.

With the alternating system some wires have been underground in Springfield, Mass., and in Denver, Colorado, and a small amount in Pittsburgh, but the voltage is only half that of the arc light systems, and even with this low voltage the lead covered cables have not been in use long enough to determine the question of their success.

The difficulty from explosions of gas has been met with many times at Chicago, New York, and elsewhere, as well as at Philadelphia, and seems insurmountable where gas is employed. At New York, men have been suffocated in the man-holes, and in the Western Union building the escape of gas from their conduits has been almost unbearable. At Detroit an explosion took place in October last, in the middle of the night in a fire-alarm conduit with close man-holes, and in which no wire had ever yet been placed. It doubtless occurred through the admixture of illuminating gas and sewer gas or other exhalations in proportions to explode spontaneously. The man-hole cover was thrown high into the air, the street torn up and the paving blocks scattered over a distance of eighty feet or more.

The problem of undergrounding arc light wires is by no means solved, but appears to-day to be further than ever from solution, owing to the utter failure of systems which apparantly had all the elements to insure success. In this emergency municipal bodies must suit their action to the facts. To legislate arc light wires beneath the ground when no practical system is presented for accomplishing that end, is actually and literally to bury the system.

When a city is so sanguine of the soundness of its judgment, the remedy would seem to be for the city to provide conduits and the necessary cables, guarantee their success, and then compel lighting companies to rent their lines at a proper figure, or failing so to do to quit the field.

Summary action on any other basis is incompatible with that justice and equity, which it is the inherent right of every person to demand and receive. Any other course is to discourage enterprise, and to ruthlessly impair or destroy capital invested in good faith.

The difficulty usually met with is a peculiar and unreasonable one. Municipal and legislative bodies view with suspicion the lighting companies, their officers, stockholders, and everybody connected with them. It seems to be assumed that because the companies make a certain showing of facts, the facts must necessarily be exactly the contrary, and they legislate accordingly. Thus, at Detroit, in opposition to letters produced by the lighting company, alleging repeated trials and failures at Washington, Philadelphia and Chicago, the then mayor, unquestionably in good faith, reported to the council, as the result of his personal investigation upon the spot, that no electric light wires had ever been buried in the city of Washington, a most glaring error, yet this was followed by a report of the committee, and unanimously adopted by the council, that underground systems of electric arc light wires were entirely practicable and were in successful use at Washington, New York and Philadelphia. At Cleveland recently, the strongest argument in the underground struggle advanced by the city, was that the wires of the Thomson-Houston Co., of Detroit, were operating underground in the Dorsett systems, whereas not a foot of arc light wire is underground in Detroit. To combat this unreasonable and unreasoning prejudice, the question whether any system yet discovered is practical and sufficient for the purpose, should be thoroughly and exhaustively examined, and an elaborate report made and published with full data upon which the conclusions are reached; this should be done by a board of competent and eminent men of national repute entirely disconnected from the electrical business, such as could be gathered from the scientific chairs of our largest colleges and polytechnic institutes, and it would rest with the interested companies of this association to contribute from their own funds or to influence the necessary contribution by the councils of their respective cities to pay the necessary expenses of such an enquiry.

ON SOME EARLY FORMS OF ELECTRIC FURNACES.

By PROF. EDWIN J. HOUSTON.

DEPRETZ'S ELECTRIC FURNACES.

ABOUT 1849, Depretz, a member of the French Academy of Sciences, conducted an extensive series of experiments on the fusion and volatilisation of different substances. During these investigations he constructed and used furnaces in which the intense heat, both of the electric arc and of incandescence, was utilised for the treatment of highly refractory substances.

Depretz's researches were undertaken for the greater part to ascertain whether even the most refractory substances would not fuse or volatilise when subjected to intense heat.

In his earlier experiments he used the electric heat in conjunction with that of other sources; in his later experiments he used the electric heat alone. As a result of his experiments he announced to the French Academy on the 16th of July, 1849, that he had fused and volatilised magnesia and other refractory bodies, and that he had fused carbon. On the 19th of November, 1849,

he announced the fusion of silicon, boron, titanium, tungsten, palladium and platinum.

Perhaps the most interesting portion of his researches related to the fusion of carbon, the results of which, for the greater part, are found in his "Fourth Note on the Fusion and Volatilisation of Bodies," read before the Academy, at the Seance of the 17th of December, 1849.

In these experiments the electric heat, which alone was used, was furnished by a voltaic battery of 600 Bunsen elements variously coupled according to circumstances. The investigations were singularly complete; carbons from the most varied sources, such as retort-carbon, carbon obtained from the calcination of sugar, or deposited during the decomposition of spirits of turpentine, anthracite, bituminous coal, graphite, and even the diamond itself.

The mode of application of the heat varied in the different experiments. In some cases the substance was simply placed directly in the voltaic arc, either while in a vacuous space, or while surrounded by an atmosphere of some inert gas. In most cases, however, the substance, in the shape of slender rods, was placed in good electric connection with two carbon holders, that formed the terminals of the battery before mentioned, and was thus raised to an intense electrical incandescence.

In some cases the substances to be exposed to the electric heat were placed in carbon retorts. The positive terminal of the battery was connected to the bottom of the retort, while the negative terminal, attached to a carbon of the same kind as that constituting the retort, was so held as to cause the voltaic arc to play directly on the carbon mass to be acted on by the electric heat. This, it will be seen, constituted an early form of electric furnace of an exceedingly efficient character.

We append the following translation, which we have made of Depretz's description of this form of furnace as contained in his communication of December 17th, 1849, before referred to, and taken from vol. 29, of the *Comptes Rendus*, of July—December, 1849:

. . . . . .

"A small retort of sugar-carbon, about one and a half centimetres in diameter, was heated by the pile connected in six series of 100 elements, until it was reduced to almost one-third of its volume. The bottom of the retort was covered with a mass of globules of the colour of graphite.

"Another experiment did not give so many globules, but we found in one part of the bottom of the retort a bluish-gray plate of graphite as if formed by the union of several flat globules.

"The carbon points, which threw the light into the retort, as well as the holder which held it, were of sugar-carbon."

. . . . . .

"The two retorts had become soft to the touch, and had acquired the properties of graphite, without, at the same time, being so easily made brilliant by friction.

"In these experiments, as in all those in which I had heated a body in a carbon retort, the retort was always made the positive pole, in order that the phenomena of transport could not interfere with the calorific phenomena."

Another form of early electric furnace was devised by Depretz in his experiments on the effect of intense temperatures on the diamond. In this form of Depretz's furnace the source of heat was solely that of electrical incandescence. The substance to be heated was placed in carbon tubes closed with corks of carbon, and the tube was then placed in the circuit of the electric source.

Depretz describes this form of furnace in this communication of December 17th, 1849, the translation of which we append:

"As I have seen diamonds exposed suddenly to a strong heat, shivered into fragments, a fact also true for all precious stones, I previously heated the diamonds, which I wished to submit to my trials. For this purpose I shut them up in tubes of carbon of seven or eight millimetres in exterior diameter, closed by corks of carbon.

"In the first experiment, I placed a diamond about two millimetres in diameter, in a tube twenty-three millimetres in length between the two carbon holders.

"The pile was enfeebled by eight days' experiment. At first the tube reddened but feebly, and finally reached a white heat. The experiment was stopped after eight minutes. The diamond had become larger, and of a grayish-black like graphite. It conducted electricity, and left a trace on paper like graphite."

. . . . . .

"In the ninth experiment I placed six small diamonds in a carbon tube seven and three-tenths millimetres in diameter, and 33 millimetres in length between the two holders. I had here arranged the pile in 24 series of 25 elements. The tube was immediately heated to a white heat and I stopped the experiment after seven and-a-half minutes. Already all the diamonds with the exception of two had been reduced to powder. This powder was without hardness, and marked the fingers and paper like graphite. One of the two diamonds not reduced to powder immediately became brilliant like characteristic graphite."

Depretz's electric furnaces were, therefore, of two types, viz.:—

(1.) Those in which the substance was heated by the heat of the voltaic arc aided more or less by the heat incandescence of the carbon retort in which the substance was placed.

(2.) Those in which the substance was subjected to the sole action of the heat of electric incandescence. It will be noticed that the electric source employed by Depretz, from the number of the elements it contained, placed at his command comparatively powerful electric currents.

LONTIN'S ELECTRIC FURNACE.

In the two early forms of electric furnaces, already described, the heat of the voltaic arc or of electric incandescence alone was utilised. Although in the Pepy's furnace the chemical affinity of the heated iron for the carbon of the diamond, undoubtedly aided the operation, and permitted it to take place at temperatures probably far below those Depretz found necessary, and although, in some of the operations of Depretz, notably those in which the voltaic arc, formed between two carbon electrodes, was caused to play on the material to be treated, the chemical affinities of the electrodes were present, and, perhaps, to some extent aided the operation, yet, in neither of these early forms of furnaces was such chemical action a leading or designed feature of their operation. They aimed at intense heat alone. They provided means for readily obtaining, in a limited space, an excessive temperature that not only permitted regulation as to its intensity, but entirely avoided the introduction of foreign gaseous or sublimed products into the furnace chamber, and thus permitted operations to be carried on that would be impracticable or difficult with furnaces of ordinary construction.

In the furnace of M. D. F. Lontin, we find a designed combination of electrical heat and electrical decomposition. The substances subjected to the operation were rendered electrolysable either by electric heat or heat of extraneous origin, and were then subjected to the decomposing action of the electric current.

In the Lontin furnace the electric source employed was a dynamo-electric machine of the series type. The idea of the inventor was to place in the circuit external to the machine such a number of his electric crucibles as would by their resistance reduce the magnetisation of the field magnets, and thus lessen the resistance to rotation of the machine.

Lontin took out letters-patent for his invention. The following descriptions are taken from his British patent No. 473, of 1875, for the "Application of electro-dynamic machines for obtaining metals, &c.," the provisional specification for which was filed on the 8th of February, 1875.

"It is well-known that electricity decomposes metallic salts, and eliminates the metal therefrom, but according to this invention it is proposed to employ only electricity generated by electro-dynamic machines, and collected under the conditions hereinafter explained. Take, for example, an electro-dynamic machine, which, as is well-known, generates electricity merely at the expense of motion. In these machines a portion of the electricity developed goes to magnetise the electro-magnets, and the remainder is at the service of the operator. If the proportion of electricity appropriated for magnetisation be removed, or if the whole of the electricity produced be so applied (and this is the condition under which it is proposed to operate), the machine may acquire such a degree of resistance to rotation that it can no longer be kept in motion.

"The principle on which this invention is based is briefly stated as consisting in the employment of an electro-dynamic machine, wherein the whole of the current produced by the machine is returned to the primary electro-magnet (simple or multiple), in which circuit are placed what are herein termed the voltameters to be operated on.

"I will now explain the invention more fully. Suppose a break to be made in any of the wires of the machine, its power will thereupon cease, and if the broken wire be reunited, its power is again renewed. If, therefore, the circuit be completed by one or more apparatus, herein termed voltameters, the machine will work, and the substances placed in such voltameter will be decomposed, the resistance of the latter diminishing, to a corresponding extent, the resistance to the rotation of the machine. If now I employ as voltameters heated crucibles containing, for example, double chloride of aluminium and sodium, and two electrodes of prepared carbon, aluminium and chlorine are obtained.

"In these crucibles may be placed any metallic salt from which it is desired to obtain the metal, the completeness of the decomposition exceeding anything hitherto attained.

By the name of voltameters, I designate any apparatus in which are placed one or several chemical substances capable of being decomposed by electricity, and I designate by the name of dynamo-chemical an electro-dynamic machine employed in the manner above specified."

Lontin points out in another portion in the above patent the well-known fact that alternating current machines are unsuited to the work of electro-chemical decomposition, and that therefore commuted or direct current machines must be employed.

Though some of the ideas contained in portions of the patent are somewhat crude, when viewed in the light of to-day, they are nevertheless far from impractical. The similarity of some of these ideas to certain electro-chemical operations carried on to-day are too obvious to need comment.

In a later patent, No. 3,264, of 1876, Lontin claims the right of applying the current produced by other kinds of dynamo-electric machines than the series machine especially referred to in his former patent, as will be seen by the following quotation.

"I reserve the right of applying in all kinds of dynamo-elertric machines the principle of sending all the electricity produced by one or more series of coils or induction wheels to the electro-magnets of the dynamo-electric machine, of introducing in a break in the circuit the apparatus in which the desired chemical or magnetic result is to be produced, the principle having been laid down in Patent No. 473, of 1875."

Central High School, Philadelphia,
December 27th, 1887.

THE PROPOSED ELECTRIC LIGHTING AT EXETER.

Last week the Exeter Town Council received a deputation, headed by the Sheriff (Dr. Davy), who attended for the purpose of presenting a memorial signed by 3,200 citizens in favour of lighting the city by electricity.

Mr. Ross, who acted as spokesman of the deputation, said that he at first thought that the cost of electric lighting would preclude serious consideration of the subject, but having gone into the question he found that it would be cheaper than gas or oil.

Alderman Jones proposed that the memorial should be taken into serious consideration, remarking that having had some little experience of the electric light at the Exeter Asylum and elsewhere, he was satisfied that it could be supplied at as cheap a rate as gas. As to the superiority of the electric light no argument was needed. From the numerous signatures attached to the petition it was quite evident that considerable interest was taken in the matter by the citizens.

Alderman Andrews inquired whether the deputation were ready with any information with reference to the comparative cost of the two methods of lighting. Although there was no question that electricity was better than gas, the council were bound to seriously consider what would be the cost.

Mr. Bowden moved that the matter should be referred to the council in committee, as it was of great public interest and importance.

Mr. Dunn urged that the Corporation ought not to consent to the introduction of a novelty simply on account of its novelty, but the new company which was in course of formation ought to bring forward a statement as to the sum for which it was prepared to light the city.

It was agreed to refer the subject to the council in committee as proposed; but at a subsequent stage of the proceedings,

Mr. Williams moved "That the Town Clerk do prepare a return showing what water power we have disposed of to private companies or individuals, and what we now retain on the river." The proposition was agreed to.

Mr. Hall then moved the appointment of a special committee to inquire into the working, cost, maintenance, and all other details connected with the electric light at the City Asylum, and if possible to compare it with that of gas. Having referred to experiments in London, he said they had only caused an addition to the rates of one-eighth of a penny, but in Exeter they would have to face the serious eventuality of an increase of 3d. in the £. He feared the lighting by electricity of the new lunatic asylum was a costly affair.

Mr. Hexter seconded the motion. After which Mr. Domvill pointed out that the question of electric lighting must be considered on broad lines. It was costing more at the lunatic asylum than the lighting did ten years ago, and more than it was likely to cost a few years hence. As an amendment, he moved that the asylum committee be asked to furnish the council with details of the original cost and maintenance of the electric installation at the asylum.

Mr. Daw having remarked that that information could not be obtained without calling in an expert, the amendment was agreed to.

NOTES.

Electric Lighting of Trains.—On Wednesday last week a number of gentlemen interested in the lighting of railway carriages electrically left St. Pancras Station by the ten minutes past ten train, on the invitation of Mr. John Noble, managing director of the Midland Railway Company, to visit the company's works at Derby, and to witness the working between that town and Manchester of the system of electric lighting of railway carriages patented by Mr. I. A. Timmis. The arrangement consists of a battery of 10 of the Union Company's storage cells placed under each of the carriages and the van, each battery weighing about four hundredweight. These batteries, which are charged by a dynamo at the station at Derby when necessary, supply a current to Swan glow lamps of 5 candle-power each, two being placed in each compartment and four in the saloon. The special feature of Mr. Timmis's system is that the lighting circuit in its normal condition is closed (when the local switch is closed) and the lamps are lighted. The lights are controlled from the guard's van, and when the guard closes the controlling circuit with a switch certain electro-magnets attached to each carriage are actuated, and the lighting circuits are all broken and the lamps extinguished. By this arrangement if any of the carriages become detached from the controlling circuit the magnets in those carriages cease to act. The result is that the lighting circuits are automatically closed and the lamps are lighted, and if they are already lighted they remain so. It will thus be seen that the guard keeps the lights off when not required to be on, but that in the event of a break away the lamps are automatically lighted. Every carriage contains its own lighting power independently of the guard's van. Besides the controlling circuit and the working circuit there is a third, the signalling circuit, by means of which communication is effected between the passengers and the guard. The cost of efficiently lighting a train of 12 or 14 carriages is stated to be equal to the consumption of half a pound of coal per mile.

The London and Brighton Railway Company have now 15 trains lighted by electricity, two running between London and Brighton, and the 13 others local ones.

Welcome as the development of the electric light is anywhere, says the *Daily News*, there is no place where its final adaptation to popular wants will be a greater source of comfort and pleasure than in the railway carriage. Nothing so much exasperates the traveller, already suffering from the tedium of a prolonged railway journey, as a bad light; while the thought of the pleasure that would be given daily to millions by the provision of a bright lamp on our railway lines ought to be a sufficient incentive to an endeavour on the part of the railway companies to supply such a want. An interesting paper by Mr. W. M. Acworth in *Murray's Magazine* for April gives the welcome assurance that some railway companies are resolutely tackling the difficulties of adapting the electric light to railway traffic.

Southampton and the Electric Light.—On the evening of Monday, the 26th ult., the Mayor of Southampton and several members of the Corporation visited the sanitary works just outside the town, for the purpose of inspecting the installation of the electric light in connection with the destructor just completed by Mr. A. I. Baron, under the direction of Mr. W. B. G. Bennett, the borough surveyor. Mr. Bennett thoroughly explained the mode of working the destructor, and pointed out certain schemes for utilising the present boilers and engines used for pumping the town sewage for lighting a large area of the district round the works with arc lamps, and the Guildhall, Huntley Institute and Audit House with incandescent lamps. It was stated that a saving over the present cost of lighting by gas would be made to the ratepayers of upwards of £100 per annum. The Mayor and Corporation were unanimous in their approval of the success of the trial, and the Chairman of the Special Works Committee was instructed to bring up a detailed report at the next council meeting, when an important discussion is expected to take place. As a result of the experiments Mr. Bennett has already received numerous enquiries about the cost of destructors and the working of the same from borough surveyors of other towns.

Mansion Lighting.—The contract for lighting Mr. J. H. Love's mansion, the Hawkhills, Easingwold, Yorkshire, has been placed in the hands of the United Electrical Engineering Company, Limited. The installation will be a large one, consisting of about 200 16-C.P. lamps. The power will be supplied from a steam-engine and boiler to be erected by the contractors in a small engine-house built for the purpose, and a set of accumulators will be provided to keep 90 to 100 lamps running from eight to nine hours.

Cheltenham and the Electric Light.—The Mayor and a special committee of the Corporation of Cheltenham paid a visit to Taunton a few days ago to inspect the electric lighting arrangements of the latter town. They spent a pleasant day and night, were highly pleased with what they saw, and carried back glowing reports to their fellows at Cheltenham.

Penzance and the Electric Light.—On Friday last week the Penzance Town Council had under consideration the question of the illumination of the borough. The committee reported that it had had laid before it by the surveyor detailed estimates regarding the probable cost of the outlay on plant, interest, and working expenses on adopting electric lighting in the borough, and also particulars of the present cost of the lighting by gas. They recommended that before any further steps were taken in regard to the matter the gas company should be communicated with, so as to ascertain their willingness to meet an increased consumption of gas by reduction in price in the shape of an increased discount or otherwise. The committee considered that, in addition to the ordinary allowance made to users of more than 5,000 cubic feet, the council might fairly claim, as consumers of over 2,740,000 feet, some further consideration, and they recommended that subject to an extra rebate of 12½ per cent., making in all 20 per cent., the council should guarantee to take an additional amount of gas equivalent to not less than one-fourth of the amount consumed for street lighting during 1887, a contract embodying such terms being entered into for three years. Mr. Dale strongly advised the Corporation, for reasons which he would adduce on another occasion, not to bind themselves to any contract, and moved that the question should be referred back to the committee. This was agreed to.

House Lighting in Dublin.—A writer in the *Irish Times* speaks of a prospectus which is in circulation among the householders of a southern suburb of Dublin, in which a company in process of local organisation offers annual terms of lighting ranging from £10 upwards. For £13 per year, it is said, a very considerable dwelling may be fitted up with this method of illumination.

Bradford and the Electric Light.—The Gas Committee of the Bradford Town Council finally decided on the 28th March upon the scheme of electric lighting to be submitted to the council at its next meeting for ratification. Instructions for taking out of quantities in accordance with plans and specifications prepared by the Corporation's electrical engineer, Mr. James N. Shoolbred, C.E., have been given. The committee have selected a piece of land in Bolton Road, belonging to the Corporation, as the site for the generating station. The necessary buildings are to be of a substantial kind, the structural work to be of local stone, with ashlar dressings, and with a solid foundation of concrete. Power is to be provided by three boilers of the Lancashire type, with Galloway tubes. The boilers will have a working pressure of 140 lbs. to the square inch. In accordance with Dr. Hopkinson's suggestion, it has been thought advisable to have the dynamos driven direct with a separate engine for each machine. It has been decided to have three sets of steam dynamos. Inverted vertical engines, with regulating gear suited to the varying requirements of an electric supply, are to be used. Dr. Hopkinson suggested the adoption of five dynamo machines, capable of delivering about 50,000 watts each; but he also advised the committee that the use of a smaller number of larger machines would be perfectly successful. The committee have decided to adopt three dynamos with an output of 85,400 watts each, and a commercial efficiency of at least 75 per cent. guaranteed by the contractor. The specifications also provide for the supply of cables and other apparatus for the distribution of the light. The copper conductors are to have a layer of insulating material of a suitable thickness, with a casing of the best lead, suitable for resisting chemical action, and protected with a waterproof sheathing. It is intended to restrict the area of supply at first to the more central portions of the town, and arrangements have been made to ascertain to what extent the supply will be needed. It is expected that the necessary works will be completed by the end of September. Tenders for the contracts are to be delivered by the 25th of April.

Water Power and Electric Lighting.—The question as to the extent to which water power may be utilised in substitution for steam in generating electricity has for some time occupied the minds of Somersetshire electricians, and special interest, therefore, attaches locally to a most successful electric lighting installation which has recently been carried out at Watts House, Bishop's Lydeard, near Taunton, the residence of Mr. John Winter, by Mr. F. M. Newton, electrical engineer. The motive power is obtained from the abundant supply of water near the lodge gates. Here there are large fish ponds fed by never-failing springs. The water is conveyed from the central pond down a 14-inch pipe with a fall of 10 feet to a turbine in a small house near the lodge. This drives a dynamo charging a set of accumulators at the house on the hill above, quite 200 yards distant. The whole of the wires are laid underground. The drawing room is lit by a central cluster of three incandescent lamps, regulated from the switch near the door. An incandescent lamp with an independent switch is placed on each side of the mantel-piece. A similar arrangement of lights has been adopted for the dining room. The billiard room is exceedingly well lit, and six pendant incandescent lamps throw an equable, steady, and powerful light on the table. All the other rooms in the house are provided with the electric light. In the hall, on the landing, and along the staircases lamps are placed, obviating the necessity of using oil lamps or candles to reach any of the rooms. A switch is placed near every bed so that the room can be lit or darkened at will without leaving the bed. In the stables the value of the light is much appreciated, for not only does it require no attention, but the danger of using mineral oils among the straw is entirely removed. The same remark applies to its use in the kitchen and in the bedrooms. The work has been so neatly and carefully done that not a single wire is visible. There are 76 lamps in all, and the house with that number is perfectly lit in every part. The turbine is sufficient for all requirements. In fact, it is not necessary to keep it working full time when once the accumulators are charged. The house is also fitted throughout with electric bells.

Telephone Extension and Obstruction.—An informal discussion took place at a meeting of ratepayers at Dore, near Sheffield last week, with reference to the proposed erection by Messrs. Tasker and Co. of a telephone line from Sheffield to Totley and Baslow. The general feeling of the meeting appeared to be that no such means of communication was required at Dore, and that the posts and wires would be unsightly and dangerous. It was stated that the late Duke of Rutland had decided not to allow the posts to be erected on his land, and objection was also taken to their erection on the New Road, Dore, which is a purely residential neighbourhood. It was further stated that if the posts are erected, legal proceedings will be taken by the property owners.

Telephone at Gorleston.—The South of England Telephone Company has just completed its line from Yarmouth to Gorleston, and has established a call-office at 118, High Street.

Barcelona Exhibition.—The authorities of the Barcelona Exhibition have now arranged for the supply of illuminated fountains similar to those which excited so much interest at the South Kensington Exhibitions, and have entrusted the contract to the Anglo-American Brush Electric Light Corporation, which is now proceeding energetically with the work.

Seel Glow Lamps.—A cable dispatch has reached us from Pittsburg stating that the American patents have been granted for Seel's glow lamps.

Electric Tramway in Vienna.—Some time ago a short experimental electric tramway line from the Central Station along the Königsgasse and part of the Ringstrasse in Vienna was inaugurated, the total length being 1·1 kilometres. The service on this line has now for some months been perfect, says the Vienna correspondent of *Industries*. The generating dynamo is established in a shed near the railway station, and the current is supplied by means of a central channel and a pair of conductors, against which slide two contact shuttles. There are at present only two cars in use. These are of the same type as those on the Lichterfelde tramway near Berlin. The transmission of power from the motor spindle to the car axle is by steel spiral cords. The central channel is of masonry throughout, with cast iron chairs for the support of the conductors, and has two steel rails on the top, leaving a slot 1¼ inch wide. Manholes are provided in several places to give access to the channel, and efficient provision is made for draining it. Messrs. Siemens and Halske, who have built this line, are now experimenting with various forms of contact shuttle. They have asked for a concession to extend the line the whole length of the Grosse Ringstrasse, now building, and they also made an offer to the town authorities to build, and equip with electric apparatus, several tramway lines which were originally projected for steam traction. In all cases they ask that the usual concession of forty years should be prolonged to fifty years, the extension of time being justified by the heavy initial outlay for the permanent way.

The Electro-Harmonic Society.—This evening will see the close of the second season of this musical association, and it is to be hoped that members and friends will attend in great force. Mr. Graves, the president of the Society of Telegraph Engineers and Electricians, has kindly consented to take the chair, and doubtless he will be well supported. Such has been the success attending these enjoyable gatherings that we are fain to believe the members will gladly welcome the advent of the season 1888-89.

Errata.—In the "Tables to Facilitate the Calculation of Strains of Overhead Line Wires," on page 337 last week, the second line of col. II. in table I. should be 6·62, not 4·62; in the second paragraph of the second column on page 338 the words between parentheses should be "(to *b* on the post, and to *c* on the stay)."

Sell's Dictionary of the World's Press.—The edition for 1888 of this book of reference for advertisers is just published. It consists of 1,350 pages, and is said to be the largest two-shilling book ever published. The information given is really valuable, especially that contained in the articles by Mr. Blake Odgers, Mr. H. R. Fox Bourne, and some others. There is also an excellent series of portraits of newspaper men, many of them being reproductions of the actual photographs by a new process. The book is not only interesting to editors, publishers, advertisers, and business men, but contains much that will interest the general reader. One aim of its publisher is to dispel the ignorance still prevalent amongst a large portion of the trading community as to the power of which they might avail themselves in the pages of the newspapers for making known their various manufactures and inventions all over the world.

The Society of Telegraph-Engineers and Electricians.—The next meeting will be held at the Institution of Civil Engineers, 25, Great George Street, Westminster, on Thursday, April 12th, when a paper on "Central station lighting (transformers *v.* accumulators)" will be read by R. E. Crompton, M.Inst. C.E., member.

Standard Lamps.—The lamp devised by Mr. A. Vernon Harcourt, which we illustrate on p. 358, is manufactured by the Woodhouse and Rawson Electric Manufacturing Company, and may be obtained from the Electric Supply Company bearing the same affix.

Triple Thermic Motor.—In the Transactions of the American Society of Civil Engineers for October, 1887, which has just come to hand, Mr. Chas. H. Haswell describes the operations and results of a single expansion, non-condensing steam engine, supplemented by the evaporation of the bisulphide of carbon and expansion of its vapour, at the Brush Electric Light Company's Cleveland Works. The author thus concludes:—"Reviewing then the elements submitted, it is presented that by the use of the vapour of bisulphide of carbon in a vessel connected to an ordinary steam boiler and engine, condensing or non-condensing, an elastic vapour can be attained greatly in excess both in pressure and volume of that of the steam that generated it; and, as an evident and infallible consequence, both increased power and economy of fuel are attained with less boiler surface and consequent wear." What say our mechanical engineers to this?

Carbons for Arc Lamps.—The manufacture of arc light carbons forms an industry of considerable magnitude in Austria, and the works of Herr Hardtmuth, in Döbling, are now turning out about 3,500 metres of carbons daily. Some improvements have recently been made in the process of manufacture, under which the homogeneity and density of the carbons are increased. These refer more especially to cored carbons. As usual, the rod of plastic material issues from the press in the form of a tube, and after drying and baking, the carbons are steeped in a heavy hydro-carbon, by which the pores left after the first baking are filled. The carbons are again baked, and the core is then inserted under a pressure not much greater than that of the weight of the plastic mass forming the core. In connection with this factory is a well equipped electrical laboratory for the testing of arc lamps. There are dynamo machines by various makers, viz., Pöge, of Chemnitz; Kremenezky, Mayer and Company, of Vienna; Krizik, of Prague; and Siemens and Halske (alternator). The reason for installing various dynamos is to be able to test any lamp which may be sent to the laboratory. There is also a spectroscope for determining the elements contained in the carbon from the spectrum of the arc, and the laboratory is equipped with the usual electrical measuring instruments and photometers. The work at this laboratory is done on a thoroughly scientific basis, and both lamps and carbons are tested so as to determine the best quality of carbon to be used for each type of lamp. At the forthcoming Jubilee Exhibition Hardtmuth carbons will be largely used for the arc lamps.—*Industries*.

The Life of Incandescent Lamps.—Mr. Joseph Moore, writing to the *Mechanical World* with reference to the long life of the incandescent lamp in the *Toronto Globe* office, says:—"If you will refer to the *Shipping World* for February, 1888, you will see a paper published which was read by the Hon. C. A. Parsons (before the North-East Coast Institution of Engineers, on December 19th, 1887), upon the compound steam turbine, of which he is the inventor, in which he refers to the remarkably long life of the lamps when on the circuit supplied by his dynamo and turbine. To quote his own words, 'We will take the installation at the Phœnix Mills, Newcastle-on-Tyne, which has been running on the average for 11 hours daily for the last two years. Out of the original 159 Edison-Swan 16 C.P. lamps, 65 are still in good condition, having run 6,500 hours at a standard brightness.'"

Navigating the Suez Canal by Night.—The regulations for the navigation of the Suez Canal by night have just been made public. The water-way of the Canal is to be lighted by means of compressed oil-gas. Steamers will be allowed by the regulations for the night passage to proceed under the same conditions as those laid down for the traffic by day, but with certain additional arrangements. In the first place, they must show to the satisfaction of the officials of the Canal Company, either at Port Said or at Port Tewfik, that they are provided with an electric projection at the stem or fore part of the vessel capable of throwing a light for 1,200 metres. They must also have an electric light, with a shade suspended over the deck, and capable of illuminating a circular field about 200 metres in diameter. The company's officials will decide whether or not the apparatus carried fulfils the required conditions, and whether or not it affords a sufficient guarantee for the steamer carrying it to be safely authorised to proceed through the Canal by night. If in navigating by night a steamer receives an order to go into a siding, she must immediately on obeying the order extinguish all her electric lights and show only the regular signal lights of a vessel lying at a siding during the night—namely, a white light at stem and stern and a watch or anchor light. When two or more steamers provided with the necessary electric light are passing through the Canal by night in the same direction, if one of them is stopped she must immediately hoist a red light at the mizen masthead and give three short quick blasts with her whistle, which must be repeated at intervals of a few seconds until the steamer following acknowledges her signal by repeating it. These signals require the immediate slakening of speed to enable the vessel to stop should it be necessary. The dredgers of the company are also required to extinguish all electric lights when lying at the sidings.

Telephone Call Offices.—A London correspondent of a Liverpool paper writes :—"There was a deputation to the Postmaster-General on Tuesday, composed mainly of business men from Liverpool, who were anxious to impress upon Mr. Raikes the desirability of extending very largely the telephone system in this country. I understood for some inscrutable reason or other an attempt was made to invest the proceedings of the deputation with an air of secrecy and of mystery. I really do not see why this should have been done. Everybody knows that in Switzerland, in France, and in Belgium the telephone system is far more developed than it is here. In this country some profane individual once upon a time defined the instrument as mechanism for swearing at the wrong man for half an hour before finding out your mistake. Every business man who uses it knows very well how on mail nights, and at other times when expedition and despatch are most essential, the telephone organisation here breaks down. It is bad and costly, and little or no efforts have hitherto been made to improve it. The deputation of Tuesday to Mr. Raikes proposed that here, as in other countries, there should be fixed telephone centres where the general public can go at any time and be put into communication with anybody who happens to be on the telephone list. The lowest charge, I believe, on the Continent is 50 centimes. It would be a profitable speculation to charge 6d. here, say, for five minutes' conversation. The deputation was introduced by Mr. W. C. Quilter, and it was accompanied by Mr. Forwood, who, I am told, takes a very considerable interest in the question. The Postmaster-General, after listening carefully to the statements made to him, and after taking elaborate notes, made something more than the usual official reply. Mr. Raikes said that he himself was in favour of the proposal, and that if anything could be done to advance it it should be done. This is a decided step in advance, which rather suggests that the Postmaster-General is anxious to make a plunge in the Post Office as Mr. Ritchie is doing at the Local Government Board and Mr. Goschen at the Treasury."

Snowstorms in Scotland.—Last week Scotland experienced a series of storms of snow, sleet, and rain of exceptional severity. In several districts railways and roads were blocked with drifted snow, and telegraphic and telephonic communication was greatly interrupted. At Dunfermline under the force of the storm great damage was done to the various telegraph and telephone lines. In many instances persons narrowly escaped being struck by falling wires. All the lines of the telephone connecting Dunfermline, Stirling, Alloa, Dundee, and Glasgow were broken. At Dundee there was a general breakdown of the telegraph and telephone wires by soft snow accumulating on and breaking the wires. Telephonic communication was also greatly interrupted. Communication between the Island of Lewis and the mainland closed last week owing to the failure of the cable. On the West Coast of Scotland little damage was done by the gales.

Lectures.—Herr Carl Rhinow lectured last week at Lowestoft upon electrical subjects, explaining the methods of producing the current and its application to telegraphic and electric lighting purposes.

Mr. A. R. Bennet, general manager for Scotland of the National Telephone Company, delivered a most interesting lecture before the East of Scotland Engineering Association on Tuesday, on "Some Recent Improvements in Telephony."

Personal.—Mr. Fredk. Walker and Mr. G. T. Hyde have commenced business as patent agents, draughtsmen, consulting engineers, and electricians at 4, Little Moorfields.

The Copper Ring.—The *Statist* has an interesting article on the demand for copper, enumerating four main sections—telegraphy, marine steam engines, locomotive engines, and brass fittings, &c. The conclusion appears to be warranted that, while the rise in the price of copper will almost certainly lead to the substitution of copper-coated iron for various purposes, there are several purposes for which copper will continue to be used largely. Meanwhile the monthly deliveries of copper in France and England continued small during March, and stocks are accumulating on the hands of the syndicate.

The Paris Exhibition of 1889.—M. Berger has issued a notice to the effect that the applications for space in Groups II., III., IV., V., and VI. have been sufficiently numerous to render it unnecessary to further extend the time. The success of the French Section is, he said, now assured. The space allotted in the main building to French exhibitors in Groups III., IV., and V., up to March 1st, amounted to 64,850 square metres, while the covered space reserved for these groups in the galleries to be built in the Champ-de-Mars is 61,950 square metres. The following classification into groups has been adopted for the official catalogues. One separate catalogue will be published for each group : Group I.—Works of art. Group II.—Education, and apparatus and materials used in connection with the arts. Group III.—Furniture and accessories. Group IV.—Textiles, clothing and accessories. Group V.—Mining, and industries connected with the production of raw materials. Group VI.—Engineering, manufactures, and applied electricity. Group VII.—Food products. Groups VIII. and IX.—Agriculture, viticulture, pisciculture, and horticulture.

New York "Electrical Review."—The appearance of our valued namesake in a bright new dress took us by surprise last week. The coloured cover, with well-displayed title, is a great improvement ; and we are pleased to see that our contemporary has not stopped at the ornamentation of its exterior, but has added new departments and more columns inside. We wish it continued success.

Electric Motors in America.—We are very pleased when our friends in the States send us information as to the progress they are making. We have to acknowledge a courteous letter from the Brush Electric Company, of Cleveland, Ohio, which contains satisfactory statements as to the business the company is doing. The business in motors, we are assured, is assuming large proportions. An order has just been received from the California Brush Electric Light Company for a power plant to be used in connection with silver mining, to the value of $40,000 for the electrical apparatus alone. The order consisted of four or five large generators and a large number of motors of different sizes. Exclusive of this plant, the California Company, which acts as Californian agent for the Cleveland Company, has during the past five or six months ordered over $100,000 worth of apparatus. There is apparently no slackening in electric light development, either, in the States. The Brush Company's works at Cleveland, which are very extensive, covering about seven acres of ground, have been crowded to their utmost capacity during the last year; in fact, during the winter months night forces were employed in the carbon and arc light departments. The company's agents all over the States report business in excellent condition, and are constantly sending in orders for new apparatus, and a plant of four 65-arc light machines and 200 arc lights was just about to be shipped to the City of Mexico. The Minnesota Brush Company is burning about 800 arc lights, the California Brush from 1,200 to 1,500.

Accident.—The Earl of Galloway, who met with an accident in the hunting field on Monday, near Oakham, causing the fracture of his left arm, was moved up to London on Tuesday. His lordship, who is known in professional circles as the chairman of the Elieson Electric Company, is reported to be progressing favourably.

Electricity and Surgery.—Dr. A. B. Carpenter announces in the *Cleveland Medical Gazette* a plan for applying electricity to the treatment of fibroid tumours of the uterus without troubling oneself about batteries. He says it is difficult to keep jar-cells and dynamos in working order, so he simply turns on the electric current from a street wire of the incandescent lighting system. He has had connections made in his office with the Edison incandescent circuit, and, by means of an ingeniously constructed rheostat circuit, the current is reduced so as to be scarcely perceptible. By means of a delicate instrument the current is accurately measured while passing through the patient's body. A switchboard is made use of, whereby the current can be increased from a fraction of a milliampère to the highest tolerant dose. The apparatus is absolutely safe, as the entire voltage of the wire can be handled with impunity.

NEW COMPANIES REGISTERED.

Tunbridge Wells Electric Light Company, Limited.—Capital £30,000 in £5 shares. Objects: To carry on in Tunbridge Wells and neighbourhood the business of an electric light and power company and also of a telephone company. Signatories: W. H. Hodkin, J. Chaverton, E. Durrant, E. Waymark, B. C. Colls, E. A. Hollingham, all of Tunbridge Wells, one share each; H. T. Chetwynd Stapylton, J.P., 72, Warwick Square, London, S.W., 10 shares. The signatories are to appoint the first directors; qualification £50 in shares or stock. Remuneration £50 per annum and such further amount as may be assigned by the Company in general meeting. Registered 29th March, by Van Sandan & Co., 13, King Street, Cheapside.

Kensington and Knightsbridge Electric Lighting Company, Limited.—Capital £250,000 in £5 shares. Objects: To take over all or any part of the shares, works, undertaking, business, property and liabilities of the Kensington Court Electric Lighting Company, Limited. Signatories (with one share each): E. Cox, 11, Gayton Road, Hampstead; W. Eacott, 9, Gore Road, South Hackney; Saml. Jordan, 36, Gertrude Street, Fulham Road; H. Gibson, 4, St. Mary Axe; E. W. Lloyd, Lancaster Road, Upper Norwood; J. Hamlin, 43, Somerleyton Road, S.W.; B. W. Ulph, 1, Findon Road, Uxbridge Road. The first directors are Granville Richard Ryder, A. Sohier Bolton, Sir Charles Grant and Roger Wm. Wallace. Qualification for subsequent directors, £100 in shares. The remuneration of the board will be determined by the shareholders in general meeting. Registered 29th March, by Deacon, Gibson and Medcalf, 4, St. Mary Axe.

OFFICIAL RETURNS OF ELECTRICAL COMPANIES.

Blockley Electric Lighting and Manufacturing Company, Limited.—The statutory return of this company, made up to the 27th March, was filed on 29th March. The nominal capital is £20,000 in £5 shares. 234 shares have been taken up, and upon 16 of these the full amount has been called, and upon the remaining 218 shares £2 per share has been called. The calls paid amount to £484 10s., and unpaid to £31 10s. Registered office, Blockley, Worcester.

Portland Electric Light Company, Limited.—The statutory return of this company, made up to the 29th March, was filed on that day. The nominal capital is £45,000 in £5 shares, but the only shares at present taken up are the seven subscribed for by the signatories to the memorandum and articles of association, and these are considered fully paid. Registered office, 48, Osnaburgh Street, S.W.

House-to-House Electric Light Supply Company, Limited.—The registered office of this company is situate at 117, Bishopsgate Street, Within.

CITY NOTES, REPORTS, MEETINGS, &c

Maxim-Weston Electric Company, Limited.

THE seventh annual ordinary general meeting of the shareholders of this company was held at the City Terminus Hotel, Cannon Street, on Wednesday the 28th ult. Mr. Hugh Watt, M.P., Chairman of the company, presiding.

Mr. John Wright, the secretary, having read the notice convening the meeting.

The Chairman, in moving the adoption of the report and accounts, said the shareholders formed an almost wholly new body from that which existed when he and his colleagues took office, and it would, therefore, be necessary to go somewhat fully into certain particulars with which they would not be familiar. The board of which he had been chairman undertook to reconstruct the company and to place it on a sounder financial basis. They had no conception, however, of the difficulties before them, or of the scant assistance they were to receive from the shareholders. Having become directors, they soon learnt that the company was virtually insolvent, and that it had no profitable contracts on hand, but some unprofitable ones, which entailed a loss of over £10,000 a year, so that liquidation seemed imminent. The shareholders at that date numbered less than 1,000, and so little faith had they in the future of electric lighting, the feverish period having passed away, that to prevent the company from going into liquidation only £550 was subscribed as new capital. It then became necessary for the directors, who believed that there was a future for the electric light, to put their hands into their own pockets, and this they did, receiving also the support of a few friends, which enabled them to find sufficient capital to carry on the business of the

company. That capital was raised for the purpose of wiping off the debts of the old company, to get rid of the old factory, which cost nearly £1,000 a year, to get rid of city contracts and other unprofitable work, and to put the company on a sound financial basis. That was four years ago. During that period the original shareholders or those who had since come in had subscribed a certain amount of capital to the company, but the bulk of the new capital to enable them to effect new works, and to lay down adequate plant to carry on a larger business had been found by the board, £4,000 to £5,000 only having been subscribed by the shareholders to date. The amount which the present board had returned in dividend had been twice the amount mentioned as having been subscribed by the shareholders. For the previous two years they had paid dividends of 7½ per cent. and 5 per cent., and not unnaturally the shareholders might have expected a dividend in respect of last year's working. He also fully expected up to November last that they would be able to pay a dividend. At that date they had carried out business and had entered into provisional contracts, entitling him to assume that, after paying a dividend of 5 per cent., there would be a considerable balance remaining. The three large contracts—over one of which they had spent, more or less, three months—ultimately fell through, leaving them with a deficiency as compared with the previous year of something like £3,000 in the profits. They had carried through an amount of business, looking to the weight of plant sold, greater than that of the previous year; but they had met with opposition of a kind which they could not foresee, and which did not exist at the beginning of 1887, from persons that was to say, who sold one pound's worth of plant for less than 20s. He then asked the secretary to read a letter which had been received from Mr. Dever relative to certain items in the accounts.

Mr. Wright read the report, in which changes were suggested in the accounts, and the method of preparing them.

The Chairman, continuing, said that before Mr. Dever's letter had been received the directors, having arrived at the same conclusion as to bad and doubtful debts, decided on transferring the whole of the balance of profit and loss account, namely, £1,555 to the reserve account, to meet bad and doubtful debts. With respect to the increase in the machinery, plant, and tools account, it had arisen from the fact that they had found that to manufacture the heavy dynamos up to 500 lights would necessitate the putting down of stronger lathes and other machinery. That had been done, and consequently the account had increased. The additional plant put down at the factory had enabled them to manufacture Maxim-Weston and Watt dynamos. He agreed with Mr. Dever that it was desirable that they should add nothing more to patents account, but as long as the present competition was going on, and improvements were coming out monthly, unless they permitted themselves to retrograde, they must continue to adopt those improvements. The expenditure incurred had been entailed entirely on Maxim and Weston patents. Reference was made in the report to the fire at the American factory last year, a circumstance which had pretty well deprived the company of the incandescent lamps, for the supply of which the company was originally formed, and without which they had been placed at very decided disadvantages. Their stock of lamps had not been adequate for the supply of their customers, and they had been compelled to tender for Swan lamps. The result was that customers had said, "We thought you had a Weston system, and in coming to you one of the contentions of your company has always been that you supply a complete system, every detail of which is the invention of one man." With respect to the manufacture of incandescent lamps, a good many present were not aware of the fact that after he joined the board he went exhaustively into that question, with the result that he found that incandescent lamps were costing them something like 17s. 6d. each, and he believed before he finished his experiments that he arrived at the conclusion that they could be manufactured at something like 3s. 9d. That fact had necessitated the dismissal of a very large number of supernumeraries, and great savings were effected. But there was one difficulty which they could not get over, the difficulty of durability. They could not succeed in manufacturing those lamps possessing a life time of half that of those which were made by the American Company. He therefore thought it was best to cease their manufacture, a proceeding which entailed a large loss, and to throw themselves on the American Company. The new lamps were very good, and, he thought, compared favourably with any in the market. There had been some very tall talk on the part of the chairman of another company in connection with the incandescent lamp. He maintained now, as he had before, that the action of the Edison and Swan Company in securing what they seemed to regard as an entire monopoly of incandescent lamps was essential in the interests of the Maxim-Weston Company. As far as their company was concerned they had been involved in no litigation with the Edison and Swan Company, and as to the question of litigation generally, it was not one that greatly concerned them, for they had the guarantee of the American Company that in the event of any litigation they would hand over to the Maxim-Weston Company a large sum of money, so that the litigation, if it ensued, which he hoped would not be the case, would be virtually by the Edison and Swan Company against the United States Electric Company. With respect to the contention of Mr. Forbes, he might say that the Maxim patent was attacked by the Edison people, but it succeeded, and that the Weston patent, which was attacked by the Cheesborough patent, also succeeded. As far as he could see, therefore, they had perfectly sound patents, which were unimpeachable, or, if impeached, could be upheld. As long as the Edison and Swan Company did not prepare to attack this company they had no intention to attack the Edison and Swan Company. During the past year they had, in the shape of sending out estimates and general work, done a great deal more than during the previous year; but for the reasons he had stated, they had not succeeded in obtaining as many orders. Whenever the company had made a reduction of 5 per cent. their competitors had made one of 10 per cent., and in many cases sustained a manifest loss on the contracts. He then went at considerable length into the principal items of the balance-sheet. He had, he said, already explained the item for patents. The auditor, very fairly, he thought, suggested for 1886 that the item, expenditure for wages, salaries, and improvements should be detailed, and that had been done week by week. He did not see that they could do anything more than they had done. If the sum was to be placed to the debit of working expenses, it would, in his (the chairman's) view, be inequitable; and in the second place, it would postpone the payment of dividends. He did not think the shareholders wanted dividends postponed, and as long as they could equitably transfer the cost of working, an amount which had been expended in relation to improvements account, he thought they were entitled to do so. It was of no use to talk of attempting to carry on an electric light company without making improvements. If they decided on such a course, he, for one, would not continue the management of the company. If they were to stand still, and simply sell what they had got, without adopting improved dynamos and improved manufacture generally, they would not succeed. Other companies had spent ten times the amount which had been spent by the Maxim-Weston Company. With reference to the stock, a considerable portion of that had been made in the first instance owing to his desire to obtain a large share of Admiralty work. What was necessary was that they should reduce the speed of their machine by 50 per cent. If they had undertaken that work then it would have cost them £5,000. After long correspondence the American Company undertook to manufacture a machine in terms of the requirements of the Admiralty contract. They got five of those machines, because the American Company would not make less, but when the machines arrived here they were condemned by the Admiralty, and the company were left with them on their hands. Up till some time in 1886, the company were almost entirely dependent for their dynamos upon America, but now, he was happy to say, they were almost entirely independent; and, in fact, he considered they were in a better position than the American Company to turn out a plant equal in candle-power to the American product at less cost, owing of course, to the protective system which America adopted. With respect to the item of shares in the Electric Sun Company, he understood that there was a prospect of that company being reconstructed, as some improvements had been made in the old Sun lamp, and he was led to believe that the item in the balance-sheet of £239 would be more likely to turn out at £2,000. With regard to the item, orders, of £15,000, a considerable portion of that was for Government orders, and he hoped to receive in respect of them a very large cheque soon. As far as he could prognosticate the future, he felt satisfied that the reserve which they had made of £1,555 would amply cover any shortcomings which might come about in the realisation of that amount. In regard to the capital issued, it was a source of regret to him that the shareholders had applied only for a trifling amount of the last issue. The new money, in view of the improvements which they were making, would have been of great assistance to the company. The directors, however, had done their duty in the matter, and had subscribed in the proportion of ten times the sum found by the shareholders. The item of creditors and bills payable figured at £2,248 on the 31st December, but since then about £2,000 had been paid, so that the liabilities of the company were of the most trifling character. With reference to the Watt patents, they were so designated out of courtesy to himself, and it was hardly necessary for him to say that others were interested in those patents, and some of the gentlemen he had had to buy out. The total sum he had spent in connection with those patents was from £2,000 to £3,000. They were originally offered to him, and as long as he was an official of the company he would consider it his duty to give the company the first offer of those patents, and as long as he remained with the company they could manufacture them with no royalty. If the shareholders expressed a wish that the Maxim-Weston patents should be continued, the directors would be speedily out of court in attempting to sell them against the existing competition. He did not think that in a public meeting like that it would be to the interests of the company to state specially the relative cost of manufacture as between the Weston and Watt patents. The company had not been involved in any expenses connected with the Watt patents beyond their having obtained the right of manufacturing with a view to meet the requirements of the trade. At present they were engaged in the manufacture of two machines on entirely different lines. He had already referred to the requirements of the Admiralty. The working plans, which were drafted for him by an outsider, were being carried out, and they had been approved by certainly one of the most eminent Government electricians. He had every reason to believe, therefore, that they would secure for those patents an enormous sale at an early day. The expense of manufacturing the new dynamos was 50 per cent. less than that of the Weston, and looking at the present prices which the Government were paying, they would be able to compete at an immense saving as compared with what they could do under the Weston system. They were enabled by the new lamp to subdivide the arc light from 15,000 to 150 candle-power. He thought, therefore, they would be able to supersede to a very large extent incandescent

lighting. Shortly after he had been appointed a director of the company the conclusion he arrived at was that they must minimise the weight of metal for the maximum of results, and, in relation to the incandescent electric light, that they must secure an indestructible filament. They were working on those lines. If they succeeded the company would have every advantage in the matter of any discovery he or any of his friends might make. They had succeeded in the matter of the arc lamp, and if they succeeded in regard to the incandescent light then they would be well in the van of electric lighting enterprise. The company could have the Watt system if they thought fit, which was 50 per cent. cheaper than the Weston, and it would give them all the requirements of an electrical company, and they would thus have to spare the Maxim and Weston patents. Recently others had been moving in the matter of supply companies, and whatever other systems might be, including the Watt, there was no one superior to the Weston for a supply company. They had ample plant in stock to lay down stations. He had an idea as to the formation of supply companies, and, if possible, of the formation of a parent supply company, giving to them on terms advantageous to the company the Maxim-Weston patents. If they did that they would obtain great advantages. Unless they were supported the Board could hardly expect to carry out negotiations and financial arrangements with that object, but they were willing to do their part. The company was not a sensational but a manufacturing one. They could take no onus upon themselves as to the market value of the stock, and he should say, looking at the circumstances of the company, that their stock was never more valuable than it was that day. Looking at the position of the company and the intrinsic merits of its patents, he had no hesitation in saying that, notwithstanding the fact that they could not pay a dividend, they were in a better position than they were ever in before.

Mr. George Howell, M.P., seconded the motion.

Mr. Louis Swaby proposed as an amendment: "That the report and accounts be not passed, but that a committee of enquiry be appointed to investigate them." He stated that he had not himself seen the report until the shareholders generally had seen it, and therefore, although he was a director, he was not responsible for the statements it contained. It was not the report of the directors at all, for Mr. Brown's resignation had not been properly accepted, and Mr. George Howell was not yet properly appointed a director. The balance-sheet was a farce, and instead of having made £1,555 profit they had made a loss. Mr. Swaby proceeded to read a number of letters which had been written by Mr. Watt and himself.

Mr. Under-Sheriff Beard, Mr. Greig, Mr. J. M. Klenck, and Mr. Jackson having spoken,

The Chairman, in reply, said that when the company was reconstructed Mr. Swaby subscribed for 4,000 shares, but he was more than a year in paying for them. The directors felt from time to time that it was not fair for them to meet a director sitting on the board who was in default of his payments. Time after time he, himself, advanced Mr. Swaby money, and ultimately took the balance of the shares off Mr. Swaby's hands, as the latter had given to the company bills which he could not meet. Mr. Swaby resigned on a former occasion because he could not pay his calls. They could not forfeit the shares of a director without some arrangement, and that was the reason why he (the speaker) had himself acquired 2,000 shares held by Mr. Swaby. He did not desire to do so, having himself such a large holding already, but he had done so in order to maintain the honour and reputation of the board. Before, however, he took those shares Mr. Swaby had sold them.

Mr. Swaby gave an emphatic denial to this statement.

The Chairman, continuing, said Mr. Brown resigned his position because he was unwell, as was also his wife, who had since died. For the year 1887 £500 was paid for directors' fees, but he (the chairman) had not participated in the payment. The reason that Mr. Swaby was not allowed to have a report and balance-sheet in the office was this, that he had charged Mr. Swaby from time to time with divulging matters affecting the interests of the company, and it was a fact also that Mr. Swaby's brother-in-law had effected a partnership with a man who had done more to damage the company than any living individual.

Mr. Swaby asked what he had to do with what his brother-in-law had done?

The Chairman said the Maxim-Weston Company was what he himself had made it. From time to time he had to find money for the company to go on with, and he had had many sleepless nights in connection with it. With regard to the Watt patents, they were not originally his inspiration. They were brought to him, and he had paid cash in connection with them in order that the company might have the advantage of them. But those patents were at the company's disposal at the lowest possible price. The previous reserve account was absorbed up to 1886. It was specially stated that it was against bad debts, depreciation, &c. The board were most willing at all times not only to have a committee, but they were anxious to have the assistance of every individual shareholder. He had always courted inquiry by the shareholders, and he could be seen at the office of the company any day between 10 and 4 o'clock. He would have no objection to a friendly committee consisting of three or four gentlemen, if they liked to adjourn the meeting. He had intended to defray the cost of Mr. Howell's services out of his own pocket. (A Voice: That won't do.) He saw no reason why the accounts should not be passed as presented, for the committee could only deal with matters affecting the future.

Mr. John Newton said he had intended to support the amendment; but after the chairman's statement it was impossible for him to do so. He, himself, had not doubted the existence of a reserve, but it was called by another name—balance of profit and loss account—and it would now be transferred to the reserve. He wished to support the chairman in charging to capital all the money they spent in developments and improvements. If they did not do that they would have to reduce their 5s. shares to 2s. 6d.

Mr. Howell explained that he had responded to the invitation of Mr. Watt to assist him on the board for a short time until this general meeting, because he understood there was some difficulty in getting on with the work.

Further discussion ensued, and finally the motion for the adoption of the report was agreed to, and a resolution appointing a committee of five to confer with the directors and report to a subsequent meeting, was accepted by the chairman and the meeting. Mr. J. Newton, Mr. J. M. Klenck, Mr. G. H. Hildyard, Mr. John Marks, and Mr. H. A. Greig, were appointed to form the committee.

A vote of thanks to the chairman terminated the proceedings.

The Telephone Company of Ireland, Limited.

THE directors in their report for the year ending December 31st, 1887, state that the number of wires, exchange and private, under rental within the Dublin district and suburbs, upon 31st December, 1886, was 915. On 31st December, 1887, the number was 936, being a net increase of 21 for the year.

The amount standing to the credit of net revenue account, including the balance of £329 1s. 5d. brought from last account, amounts to £4,314 3s. 6d., against £3,629 2s. 4d. for the year 1886. Out of this sum there has been paid the interim dividend upon the preference shares for the half-year ended 30th June, 1887 (£858 19s. 1d. paid in July last), also the interim dividend upon the ordinary shares (£656 5s. 0d. paid in August), leaving an available balance of £2,798 19s. 5d., as shown in the balance sheet, since reduced, by payment (on the 14th January) of the dividend upon the preference shares for the second half of the year, to £1,858 6s. 8d., which the directors propose to allocate as follows:—For the payment of a dividend on the ordinary shares for the second half of the year, at the rate of 1¼ per cent. per annum (absorbing £1,093 15s.), against ¾ per cent. for the corresponding half of 1886, and equivalent to a distribution of 1 per cent. for the entire year, against ¾ per cent. for the year 1886, and to place to the credit of the reserve fund, £398 10s. 3d. (being 10 per cent. upon the net profits of the year), carrying forward the balance of £366 1s. 5d. to credit of the current year, as against £329 1s. 5d. brought in from 1886.

Telephone Company of Austria, Limited. — The directors have declared an interim dividend at the rate of 6 per cent. per annum on the preference shares for the six months ended March 31st, payable, less income tax, on and after April 9th.

Oriental Telephone Company, Limited.—The directors recommend a dividend for the year ending December 31st of 2½ per cent., tax free, on the paid up capital other than the vendor's shares.

TRAFFIC RECEIPTS.

The Cuba Submarine Telegraph Company, Limited. The number of messages passing over the lines of this company during the month of March was 4,919, estimated to produce £3,800, against 4,775 messages, producing £3,727 in the corresponding month of last year. The receipts for the month of December, estimated at £3,300, realised £3,373.

The West India and Panama Telegraph Company, Limited. The estimated receipts for the half-month ended the 31st March are £3,763, as compared with £3,43[illegible] in the corresponding period of 1887. The December receipts estimated at £5,577 realised £5,612.

The Western and Brazilian Telegraph Company, Limited. The receipts for the week ending March 30th, 1888, after deducting the fifth of the gross receipts payable to the London Platino-Brazilian Telegraph Company, Limited, were £3,491.

The Direct Spanish Telegraph Company, Limited. The estimated receipts for the month of March were £1,900, against £1,863 in the corresponding period of last year.

The Brazilian Submarine Telegraph Company, Limited. The traffic receipts for the week ending March 30th amounted to £4,315.

ABSTRACTS OF PUBLISHED SPECIFICATIONS, 1887.

275. "Improvements in and apparatus for effecting the distribution of currents of electricity." R. E. B. CROMPTON and J. H. F. SOLL. Dated January 7. 8d. Claims:—1. The arrangement and use of regulating switches, consisting of circular brushes forced through ring-shaped contacts, substantially in the manner shown. 2. The arrangement or construction and use of ring-formed contacts split at one side so as to ensure a good contact on to the circular contact brush, and which enables same to be adjusted to

compensate for wear, substantially as set forth. 3. The arrangement and use of one or more rows of contact rings side by side with operating mechanism, to act as a regulating apparatus to accumulator or other electric batteries, substantially in the manner shown. 4. The combination of parts of means or apparatus for operating several circuits requiring a current of different E.M.F. from one and the same source of electricity by means of several rows of ring contacts, arranged as described and shown. 5. The apparatus, described and shown, for use as a means of varying the E.M.F. of the currents employed for lighting scenery and other parts of theatres, so as to enable several currents of varying E.M F. to be obtained from one source of supply.

1331. "Improvements in commutator brushes or contact pieces for electrical apparatus." D. HALPIN and I. A. TIMMIS. Dated January 27. 8d. Claim:—Mounting the brushes of contact pieces of moving commutators upon sliding or rocking frames, to which a to and fro motion is imparted by worm wheel or other gearing from the commutator shaft, such that the brushes are made to slide to and fro upon the surface of the commutator in a direction at a right or other angle to its motion, the framing carrying the brush holders being at the same time capable of angular adjustment, for obtaining the most suitable lead for the brushes, substantially as described.

1390. "Improvements in dynamo-electric machines and electro-magnets." R. C. JACKSON. Dated January 28. 4d. Claim:—In dynamo-electric machines and electro-magnets the use of an alloy of iron with aluminium.

1499. "Improvements in laying and insulating underground wires intended for use as conductors of electricity." T. O. CALLENDER. Dated January 31. 6d. A case or trough of the dimensions required, which may be advantageously formed rectangular in shape, is made of bitumen concrete in the required lengths. Such lengths are carefully jointed together "in situ," so as to form one continuous case or receptacle for the conductors, these conductors are each first insulated preferably with the bituminous material described in the specification of Callender's patent, dated October 11th, 1881, No. 4409, and are protected in the usual manner by tape braiding or otherwise. When desired they can be stranded into cable form or covered in groups by the usual machinery. As many of such conductors, whether single or in cable form, as are required are laid in the case or trough, with a space more or less between each, being held in position by spacing bridges placed in the case or trough at suitable distances. The whole vacant space is then filled by running in refined bitumen in a molten state, care being taken that it is not of too high a temperature to char, burn, or otherwise injure the insulator on the cables or wires, and also that no vacant space is left either between the individual conductors or between such conductors or cables and the case or trough. By employing the trough or casing with the wires laid and embedded in the manner above described, and employing the materials above mentioned, groups or systems of underground wires can be laid more efficiently and cheaply than by any method hitherto adopted. There is 1 claim.

1609. "Improvements in and connected with electrically wound clocks." W. J. BARNSDALE. Dated February 1. 8d. Claims:—1. In electrically or automatically wound clocks a pin wheel provided with pins of graduated length adapted to engage with the hammer tail, said pin wheel making a complete revolution each time the hour is struck, substantially as set forth. 2. In electrically or automatically wound clocks a snail or stepped wheel combined with a pivoted lever adapted to operate the arbor carrying the hammer tail, and thus regulate the number of pins with which the hammer tail will engage for any given hour, substantially as set forth. 3. In electrically or automatically wound clocks a spring lever and clutch mechanism adapted to alternately put the indicating and striking winding barrels into engagement with the motor, substantially as set forth. 4. The general arrangement and combination of parts forming the improved clock, substantially as described and as illustrated in the drawings.

1667. "Improvements in the application of electricity to illuminative and other purposes in theatrical and analogous representations." M. MCMULLIN. Dated February 2. 8d. Claims:—1. The manufacture and use of portable self-contained electrical batteries, fitted to wands, swords, flag-staffs, banners, staves, crosses, brushes, hats, head gear, and other articles in connection with theatrical performances, and analogous representations, independent of connections either with the person or otherwise, substantially as described and illustrated on the drawings. 2. The general arrangements, construction, and combination of parts, constituting the improvements in the application of electricity to illuminative and other purposes, in theatrical and analogous representations, substantially as described and illustrated on the drawings.

1738. "Improvements in dynamo-electric machines." C. D. ABEL. (Communicated from abroad by the firm of Siemens and Halske, of Berlin.) Dated February 3. 8d. Claim:—In continuous-current dynamo-electric machines with Paccinotti ring, the use of exciting electro-magnets situated entirely within the ring, so that the exciting poles thereof are only presented to the inner surface of the ring, substatially as described.

6584. "Improved electric marine governor." R. B. MADDISON. Dated May 5. 8d. Consists:—1. Of a cylinder fixed horizontally on to the stern post of the vessel, open at the fore end with a perforated cover on the after end, containing a piston situate at the front end, and a spiral spring between the piston and the aforesaid cover; this cylinder is fixed just below the surface of the water when light ship. 2. Of a tube leading from the shell plate to the after peak bulks-head in which there is placed a stuffing box and gland, being similar to a stern tube, through the tube already described the piston rod is led, the piston being attached to the outer end, and the inner end is tapped so that a thumb screw may be put in, by which means the rod can be lengthened or shortened. 3. Immediately above or below the piston rod aforesaid (as may be required), of an electric cell box containing acids necessary to produce the electricity required, from which box there will be a small nipple projecting to the horizontal line of the piston rod and thumb screw. 4. A spiral spring between the piston and perforated cover as aforesaid, which is so sensitive as to give with the current, or velocity of water caused by the motion of the vessel, and by so doing the aforesaid thumbscrew is removed from the nipple, but as soon as the water leaves the light ship water line, it also leaves the cylinder and consequently there is no resistance, then the spiral spring behind the piston, forces the piston forward which causes the end of the rod or thumbscrew to press the nipple, causing the electricity to be conveyed instantly (by means of an electric wire), along the tunnel into the engine room where there will be a magnet affixed to the wire. This magnet is placed close to the end of the slide valve spindle; on the end of this spindle there is a dial placed corresponding with the aforesaid magnet, therefore as soon as the nipple is touched the magnet is charged with electricity, and opens the slide valve instantly admitting steam into an ordinary cylinder, and as soon as the cylinder at the stern touches the water again, the velocity of water coming against the piston compresses the spring, thus removing the rod from the nipple, thereby discharging the magnet and the slide valve spindle which is again brought into its normal position (that is admitting steam for the return stroke) by means of a small spiral spring situated between a collar on the slide rod and a bracket from the cylinder, this cylinder being of the ordinary class with a direct lead (if possible), to a lever keyed in the usual way to the throttle valve main spindle. 5. It is also proposed to key another lever to the aforesaid spindle (in like manner) and lead a rod from the latter lever to another lever keyed on to another spindle on which there will be a throttle valve to be placed in the exhaust column, and it being connected to the main spindle, the feed and exhaust will be shut simultaneously thus expelling all power. 6. It is also intended to make and set the slide valve so as to use steam and vacuum for closing the throttle valves, and vacuum only for opening the same, thus never admitting steam to the front of the piston. The claims are 2 in number.

11200. "Improvements in electrically controlled unison motors." A. J. BOULT. (A communication from J. F. McLaughlin, of Philadelphia.) Dated August 16. 8d. Relates to an improved automatic electro-mechanical unison motor. The claims are 9 in number.

11917. "Improvements in and relating to continuous-current dynamo-electric machines and electro-motors." R. KENNEDY. Dated September 2. 8d. Claims:—1. In continuous current dynamo-electric machines or electro-motors, the arrangement and combination of the parts so that two independent magnetic fields are produced by one electro-magnet, or three fields by two, or four fields by three, and so on, with only one extra armature, all substantially as described in reference to and shown in the drawings. 2. In continuous current dynamo-electric machines or electro-motors, the combination of two armatures with one electro or field magnet, all substantially as described in reference to the drawings. 3. In continuous current dynamo-electric machines or motors, the combination of two armatures with three field magnets, all substantially as described in reference to and shown in the drawings.

13091. "Electric motor for clocks and for other industrial purposes requiring small power." M. VIAU. Dated September 27. 8d. The motor consists of an automatic interruption (that is to say, an electro-magnet, the armature of which acts as an alternate maker and breaker of the circuit, and a so-called Huyghens's pulley elevator, which is actuated by means of a ratchet wheel operated by the motion of the said armature. The claims are 2 in number.

13092. "Improvements in and relating to the manufacture of material for the production of carbon filaments for incandescent electric lamps and other articles." W. R. LAKE. (Communicated from abroad by La Société A. Cruto & Cie., of Turin, Italy.) Dated September 27. 4d. Claims:—1. The employment of ulmic or similar substances to produce a material fit for the fabrication of carbon filaments for incandescent electric lamps, as well as for the production of other articles in use in science and arts, as described. 2. The process employed for obtaining ulmic acid in the form of a paste capable of being wire drawn or moulded into any desired form with the view of obtaining articles as already stated, by following all the operations successively described and specified.

13509. "Improvements in and relating to telephonic apparatus." C. BELL. (A communication from abroad by L. M. Ericsson, of Stockholm.) Dated October 5. 6d. Claim:—In a telephonic apparatus or instrument the forming of a shunt connection or circuit, so that, should the hook lever contacts become inoperative, the current can nevertheless pass through a circuit of greater resistance from the line connection to earth, and when the hook contacts are in working order the current passes through the circuit connection of least resistance, all substantially as described in reference to and shown in the diagrams.

13722. "An improvement in electrical secondary batteries." C. E. PONDER, J. MACGREGOR, and P. HARRIS. Dated October 10. 6d. Claim:—The improvement in electrical secondary batteries, consisting in wholly encasing their cells in paraffin wax so as to perfectly insulate and hermetically seal them, substantially as described and explained, and as illustrated in the drawings.

13736. "Improvements in electric spinning and twisting machines." A. S. KIMBALL and G. L. BROWNELL. Dated October 11. 8d. Relates to that class of machines for spinning or twisting, in which a series of revolving spindles are employed, and it has for its objects: to provide means for rotating the spindles without the use of the driving bands, which are usually employed for that purpose; to synchronise the rotation of the spindles in each spinning or twisting frame, or in a number of frames; also to regulate their speed with reference to the speed of the drawing rolls, or other mechanism for delivering the strands to the spindles, and further to reduce the friction of the revolving spindles; and we accomplish these objects by means of the mechanism described and illustrated in the drawings. The claims are 5 in number.

12752. "Improvements in underground conduits for electric railway and other appliances." A. J. BOULT. (A communication from Elias E. Ries, of America.) Dated September 20. 8d. Relates to an underground conduit for the supply conductors of an electric railway, or for the traction cables of a cable railway, or for both the traction cables and the supply conductors, where the respective systems (cable and electric) traverse in common the same course or street for a certain distance. Relates further to the accommodation of conductors of electricity for the transmission of telegraphic, telephonic, heating, lighting, or power currents; and for the ducts or tubes for pneumatic or hydraulic systems of communication; in short, to a single combined way wherein manifold systems of intercommunication controlled from a terminal station or stations now in use can be all separately housed with economy to the projectors and safety and convenience to the general public. The object of the invention is to attain this end by simple means; to produce a structure that will resist as far as possible the destructive action of the soil; and to enable the various parts to be cheaply and readily set in place, and those subjected to wear to be removed without difficulty. The claims are 23 in number.

13778. "Improvements in automatic electric signalling for railways and apparatus therefor." W. WALKER. Dated October 11. 8d. Relates to improvements on the system or method of automatic electric signalling for railways, and apparatus therefor described in letters patent No. 14,105 dated 2nd November, 1886, and it has for its object to simplify such system or method, to render the same more economical, and to provide a simple but efficient contact apparatus by which the signals are operated. The claims are 3 in number.

13864. "Improvements in incandescent electric lamp holders and other like fittings." F. H. ROYCE. Dated October 13. 6d. Claims:—1. In an electric incandescent lamp holder or other like fitting, the use of a coil or a contact spring placed on the plunger and connected at one end to a half moon plate, and at the opposite end to the plunger, in order that the electric current may have a continuous metallic circuit, substantially as described. 2. In incandescent lamp holders, for the purpose of attaching the tube to the body of the holder, the use of a bayonet joint in combination with a screw for tightening and holding the same, substantially as shown and described.

13974. "An improved electric alarm for varying levels and pressures." A. SIEGMANN. (Communicated from abroad by C. Marohn, of Germany.) Dated October 14. 6d. Claim:—In an electric alarm adapted to be combined with a dial and index gauge, the combination of two spring ends obtruding into the path of the index, and adapted to be pressed back by said index at the respective ends of its determined path, with spring plates carrying springs or intermediate contacts on them adapted to establish contact with springs forming parts of an electric circuit, and which are adapted to respectively close said circuit by contacting with respective contact screws in said circuit under the pressure transmitted from the index, substantially as described with reference to the drawings.

14209. "Improvements in electrical apparatus for prevention of corrosion and incrustation in steam boilers." H. W. RUSDEN. Dated October 19. 6d. Claims:—1. The use, for prevention of corrosion and incrustation in steam boilers, of electrodes or anodes so situated as not to expose two dissimilar metals to the water whereby local galvanic action in the electrodes is obviated, the arrangement being such that the boiler is negatively, and the electrodes positively charged either in the boiler or from an external battery, substantially as described. 2. The use in connection with electrodes for prevention of corrosion and incrustation in boilers, of means such as a wire connecting a commutator or switch of an electric battery with an insulated conductor extending into the boiler, for enabling the electrodes to be charged negatively, without involving positive charging of the boiler, substantially as described.

14893. "Improvements in generation of electricity." L. G. WOOLLEY. Dated November 1. 6d. Claim:—The boiler in combination with a steam pipe, smoke stack, or other conveyor of heated material extending therefrom, a thermo-electric pile placed thereon, the steam engine, and the dynamo driven thereby, the wires extending from the thermo-electric pile being connected to the dynamo for the purpose of charging it, substantially as shown.

14901. "Improvements in electric batteries." C. H. GOODWIN. Dated November 2. 6d. Consists in employing, for the manufacture of electric batteries, a body capable of absorbing and retaining, in a moist state, sal-ammoniac or other liquid requisite for producing an electric current. The said body can be either textile substances, such as wool, cotton, hemp, and such like, or vegetable substances such as sawdust, wood paste, paper pulp and such like. There is 1 claim.

CORRESPONDENCE.

Fire Office Rules.

It is whispered that the proposed new rules of the Society of Telegraph Engineers and Electricians relating to electric light installations may not be materially different from those of the Phœnix Fire Office; if so, what possible purpose can their promulgation serve?

Moreover, the Phœnix rules are copyright, and there may be something to say on that score presently.

Will anything be gained by attempting to establish a kind of dual control? On the contrary, will not the beneficial effect of the moral sway hitherto exerted be seriously weakened or altogether destroyed? There has been a certain safeguard to the public in the fact that contractors have generally evinced a readiness to conform to the Phœnix rules, and as a natural consequence the class of work has been steadily improving, and the "cutting" firms have been finding it increasingly difficult to oust the truly conscientious contractors. If users of the light discover that there is need (real or imaginary) of a rival set of regulations, the growing confidence in this branch of electrical engineering will be shaken. If there be any necessity for revision or for enlarging the scope of the Phœnix rules, would it not have been possible to arrange a a meeting of *representative electrical contractors* (upon whom the due execution of important works must fall, and not—I say it with all respect—upon the *consulting electricians*) at which Mr. Musgrave Heaphy, whose enthusiasm is admitted, and to whom belongs the credit of compiling the Phœnix rules and bringing them in successive editions to their now complete form, might be present, and conclusions arrived at satisfactory to all the parties concerned?

It is to be hoped that the members of the profession will insist that an independent committee be appointed by the Society to investigate and report upon the facts of this unfortunate dissension, and that such committee may invite Mr. Heaphy to give evidence and produce any correspondence that may have passed between himself and the Council of the Society on the subject, which is of the utmost importance and merits careful investigation.

It is, perhaps, a question whether the council possesses the right to act in this matter without consulting the main body of members of the society, and one thing is certain, viz., that scarcely a month will ever pass without the point involved being raised in some form or other, so that a settlement should be effected forthwith.

What we really need now is an efficient leader, and anyone possessing the requisite qualities who will come forward at this juncture will earn the lasting gratitude of the whole profession.

Contractor.

The Block System.

Your leaderette on page 331 of your issue of the 30th ult., relative to the block system on the North British Railway, is somewhat inaccurate and misleading, as it would cause one to infer that this company has not adopted the block system to any great extent on its lines, whilst the fact is that the block system has been in operation for very many years over almost all the double lines, and what the company has determined to do is to complete the system where it was incomplete, which

is only to the extent of a very short distance, in two or three parts of the system where block working could not be introduced without impeding the traffic, until new signal cabins and interlocking apparatus was provided.

The sum of £10,000 referred to is to cover this, as well as the block telegraphs proper, which will involve a very small portion of the sum named.

A. F. Clement, *Supt. of Telegraphs, the North British Railway Company.*

April 4th, 1888.

[We quite understood—as our leaderette shows—that the block system was in operation over some portion of the North British lines. We are glad to learn, however, that we were in error in supposing that it was only a small portion, and that the directors have not been so backward in adopting a very important safeguard as we judged they were from the accounts which reached us.—EDS. ELEC. REV.]

Catalogues.

We have worked up a very busy and daily-increasing connection with the telegraph world as the result of manufacturing sound articles, and supplying them at a reasonable rate—a fact which seems to have worked up some of our Manchester friends into a state of "fight," at once amusing as well as interesting; but the great importance which Messrs. Glover seek to attach to our having copied, in part only, and even then with striking omissions, a common form of printed card or price-list, which is much like that of other wire coverers, and in one or two of the cases cited, precisely the same, is simply childish, and all unbiased people will see that it *really* means *jealousy*.

Unlike Messrs. Glover, we prefer to advertise ourselves in a legitimate manner; but we gladly take this opportunity of inviting comparison between our catalogue and Messrs. Glover's card, when your readers will be in a position to judge of the spirit and reasons which are at the bottom of this matter.

We can only say in reference to the last paragraph of Messrs. Glover's letter (from which we are led to infer that they are the very paragons of righteousness themselves) that we shall treat such insulting pharisaical humbug with the contempt which it deserves.

The Telegraph Manufacturing Company, Limited,
per J. SLATER LEWIS,
Managing Director.

April 5th, 1888.

Insulating Commutator Bars.

I shall be obliged if you will kindly say through the REVIEW whether you would recommend asbestos or mica for the insulation of the commutator of a 110 v. 72 a. shunt-wound machine. The reason for the above question is that the present insulation is plaster of Paris, which keeps flying out.

Commutator.

April 3rd, 1888.

[We would prefer to leave the answer to this question to any of our readers who have had years of experience in the insulation of commutator bars, although we do not anticipate that they will suggest asbestos.—EDS. ELEC. REV.]

Mr. Sprague on his Defence.

The idleness enforced by convalescence from typhoid fever has given me the opportunity to reply at some length to certain communications which have appeared in your journal from English electricians reflecting upon the work which has been associated with my name. These communications having appeared some months since, I will very briefly refer to them.

In October of 1886 there appeared a partial description of the Sprague electric railway system with particular reference to its application to the elevated railroads of New York, and considerable discussion of the experiments which were then being conducted on the Thirty-Fourth Street branch, and which have since been suspended during the preparation of other experiments on a more extended scale.

In an editorial of October 22nd, 1886, in a flippant and certainly ill-considered manner, you criticised this work, and stated that pretty nearly every element for which any novelty is claimed was old and was common to Aryton and Perry, Edison, Siemens, or Reckenzaun. In latter numbers, those of October 29th and November 19th, a description of some of the variety of motors which have been constructed by myself was also published. Besides some adverse comments on the part of your journal, certain articles appeared therein from the pens of Prof. Thompson, Mr. W. M. Mordey, and Messrs. Ayrton and Perry, which, unquestionably based upon ignorance of the facts, did an injustice to this work, which ordinarily would not be expected from such sources. I was then, as now, overwhelmed with work. A detailed answer to many of the assertions which were made seemed to demand too much of the time which was already too short in which to do that which my duties required of me, so I addressed a communication to the editor of the New York *Electrical World*, which appeared in the issue of February 12th, 1887 (ELECTRICAL REVIEW of February 25th) in which I did not decline, as asserted by Prof. Thompson, to discuss the issues that had been raised, but simply deferred it, and suggested that any of these gentlemen and myself build two electric motors on working models and designs dating back not less than five years, that is, based on models of 1881; and I specified certain conditions of working. I suggested that these machines should be submitted to two gentlemen who are of such character that any decision, either as to the machines themselves or to the evidence that might be submitted as to their originality, would be unquestioned. In the ELECTRICAL REVIEW of February 25th, there appeared a somewhat facetious and remarkably inaccurate communication from Prof. Silvanus Thompson so suggestive of everything that any man should resent that I cannot longer delay a somewhat specific answer to his statements, in which I shall point out the gross errors into which these gentlemen have fallen, and perhaps put the public in possession of facts from which they shall, independent of either Prof. Thompson or myself, judge as to the degree of credit which should be given in this matter of the transmission of power.

Formerly I considered technical journals of the standing of the ELECTRICAL REVIEW, and professional men whose time is supposed to be given to instruction and critical research as being somewhat above the bias of personal feeling, and at least not accustomed to commit themselves to statements in criticism of scientific work without a thorough knowledge both of the subject concerning which they write and the facts pertaining to progress in it. The grave error into which both yourself and all of these gentlemen have fallen is that you took apparently the date of publication or description of some of the writer's work as it appeared in the latter part of 1886, and concluded that this was the date for which he should be credited. I cannot expect to be free from criticism, nor do I desire to be so exempted when that criticism is honest and based upon facts; but it should be well to point out that there are four dates in almost all work with which a man should be conversant before he undertakes a critical review of it. One of the dates is that of conception. Of this, of course, no one except the originator and his witnesses can be aware until it is brought out in a court of law or by due legal process. The second is the date of first application for a patent, generally in one's native country. The third is the granting of that patent, and the fourth the published description of the work which is based upon it.

Instead of taking the trouble to ascertain at least the second date to which I have referred, most of the

criticisms have been based on the date of the publication. If it had not been so it would have been utterly impossible for them to have made many of the statements that have been put forth unless it was from a wilful desire to misrepresent the facts. Due allowance, I suppose, must be made for the personal prejudices of inventors. Mr. Thompson, Mr. Mordey, and Messrs. Ayrton and Perry are probably no more free from this than the writer. We are each apt to look with biased eyes both upon the value and the novelty of our own inventions. The fault is probably common. But it hardly seems necessary that our view should be so biased that it is impossible for us to see either merit or originality in any work which may possibly be similar to that which we have in hand. Every technical paper which has ever approached me knows perfectly well that for three years I absolutely refused to allow any published description that it was in my power to prevent of any part of the work in which I am engaged; and why this was necessary involves to a certain extent a personal explanation, which I will be very glad to avoid, but which here seems necessary.

The writer has been under contract to have his work developed and patents issued in several European countries, and in the United States. Those who are unfamiliar with the patent laws of Europe and America do not appreciate the difficulties which one encounters in attempting to protect any work in which he may be engaged in different countries. The United States law has been held to be something of the following:—

Any United States patent which is actually issued after the date of a corresponding foreign patent, is limited by the expiration of such patent. American patents are dated at issue and not on filing; certain foreign patents are dated at the hour of application. A United States patent ordinarily would run for 17 years, while many foreign patents, unless renewed, would only run for one year. In the United States a patent, after application, may be pending in a Patent Office, because of interference and what-not, for a period sometimes as high as five years, and some of the writer's patents have been in the office for over three years; whereas abroad patents are generally issued in a comparatively short time, and sometimes in a perfectly definite time after the date of application. It follows, then, that if a patent is applied for in the United States, and one wishes here to be protected, it is impossible to permit the filing of the foreign patent until the actual date of issue in the United States.

A person may then be placed in this unfortunate condition: He may be the originator of a most valuable machine; he applies for a patent in the United States, and because of some complications his patent may not be issued for three or four years. Meanwhile it is impossible for him to protect himself in European countries without jeopardising his home interests. He may prepare his papers and let them remain in his attorney's office month after month or year after year, until a few hours before the actual issue of the patent in the United States, when he must cable to his attorney to have the European patents applied for. Meanwhile precisely the same machine, although it may be two years later, may have been invented by someone else, the foreign patents applied for, and descriptions scattered broadcast over the continent. On the other hand, while the patent is pending in the United States, publication of the description of it is pretty apt to produce an interference which may delay the patent and prevent a foreign patent being taken out at all; and if any description is made before the application of the foreign patent, this latter is invalidated.

Possibly these gentlemen, who certainly have not had the experience, as the Patent Office records show, in these different countries which they might have had, will now appreciate the following statement: that very many of the prominent features in the Sprague system were nearly five years old when their description was published last fall, and represented the results of my work, not only at home, but in several countries where my duties had called me. What right, then, in view of this fact (which might certainly have been ascertained without any trouble), has the ELECTRICAL REVIEW, for instance, to make the assertions which it did editorially on October 22nd. Let me refer to them with some more particularity.

In this article priority of invention is awarded to nearly every man who ever had anything to do with electrical railways on many of the most important points in the Sprague system. In addition to this there is such a number of utter mis-statements that a refutation of them is necessary. In the first place, a third rail was not claimed as original with me; it was simply necessary to mention it in giving a description of my system. The double system of tracks was supplied from a common source, and the working sections are always in connection with the main conductors except in case of accident; while the contrary is true of the Ayrton and Perry system. Nothing new was claimed in the bodies of the armatures which I used. The windings, however, which have never been described, were not just the same as the Siemens armature. Mr. Reckenzaun was not the originator of the application of two distinct motors for a car, and no one ever controlled two motors in the same general or specific manner in which the motors were controlled on this elevated railroad car. In fact, it was the first instance in which two shunt-wound motors were ever handled together.

When one considers the relation of the motor and initial electromotive forces, and the facts that if not properly proportioned and very perfectly governed one machine would be driving the other as a dynamo, which would not ordinarily be the case where two series machines are used, the importance of this trial will possibly be appreciated. It is further stated that the use of motors to produce the requisite brake power was resorted to by Reckenzaun several years since. I believe it is true that Mr. Reckenzaun and others have used a motor for brakes by closing the armature circuit of a series machine upon a resistance, or short-circuiting the armature and forcing the motor to run as a dynamo; but the raising of the motor electromotive force above that of the line, and thereby producing an actual reversal of the current in the armature without any change whatever in contacts, by independent regulation of shunt-fields for the purpose of braking, has never been accomplished prior to the actual accomplishment of that work by the writer, nor has it ever been proposed in any work published in the English, French, or German languages before it was originated by me.

As a further sample of the inaccuracy with which this article was considered, I will take the following extract:—

"According to the source from which we are quoting, 74 horse-power is required for each train of four cars and engine, and Mr. Sprague proposes to transmit this power by two pinions upon each motor shaft, $3\frac{73}{100}$ inches diameter, 3 inches face, and having 13 teeth; each tooth thus having a thickness of about $\frac{3}{8}$ths of an inch."

I suppose that this was intended as a criticism upon the mechanical design of the gears. A careful perusal of the article in question shows, not that it takes 74 horse-power to run the train but, on the contrary, that it requires a great deal more; that for the entire trip, including stoppages, starting and stopping, and on different grades, the averaged horse-power developed for each 100 ton train was 74 horse-power; a fact that has been determined by actual indicator cards taken over the entire road continuously, and also by independent calculation by the writer; and the actual capacity of each locomotive is really about 170 or 180 horse-power.

Now it was not proposed to handle this entire train by two motors and four gears, as one would infer from the criticism which I have referred to; but it was simply proposed to handle one car by two motors. It would be well in criticising mechanical dimensions to consider all the facts. In determining whether a certain amount of horse-power can be transmitted by any mechanism, the speed must be considered as well

as the strain, they vary inversely; but, in fact, any consideration based simply on power is unnecessary because the greatest strains are those which occur at the moment of starting, and practical experience has shown that these gears, which when running at a speed of 1,200 feet a minute are actually only required to transmit each about 10 H.P., have their greatest strain at the moment of starting, or when on the point of slipping, and by the severest possible tests have amply proven both their strength and reliability, and have never as yet shown under any conditions the slightest sign of weakness.

The method of mounting, in which the thrust of the gears is opposed by a spring, allows a much higher safe speed of gearing and much greater sudden strain than would be possible were the gears fixed; and in no case where this principle has been followed out has there ever been a single failure. Possibly the plaint of the ELECTRICAL REVIEW in its editorial of February 25th would not be repeated now because, so far as that journal is concerned, I am right, and entirely right, in taking exception to the criticisms it has made as being hasty and ill-advised, a course of treatment which no technical paper which is supposed to desire to get at the truth has any right to pursue.

The 300 horse-power motor car which was described in your issue of November 25th, 1886, is nearly completed and will in due time be fully described. I may possibly hope that it has some novel features, but by the time a published description of it is given I will probably find that it, as well as everything else with which I have had to do, will be claimed to be antedated by some yet unborn electrician.

Leaving, however, for the present, these questions of the application of motors to railroads, I will consider at some length the discussion which has arisen concerning certain laws enunciated by the writer, and the criticisms which Messrs. Thompson, Mordey, and Ayrton and Perry have made upon them. In the development of certain classes of motors the writer enunciated the following law: That in a motor with the armatures and the field independently supplied, the work which the motor armature will do in a given time, its economy and efficiency, are all practically independent of the strength of the field magnet provided the translating devices between the motor and whatever is the receiver of its energy are not limited as to the rate of transmission of the motor's speed, and that in all cases where the motor is working on a constant potential circuit and not at its maximum capacity, in order to increase the maximum effect either of speed or power, or both, or to compensate for any falling off of potential in the line, it is necessary to weaken the field magnets instead of strengthening them and *vice versa*, provided, however, that the counter electromotive force of the motor is more than 50 per cent. of the initial, that is, if working on what I call the first or highest economy, and that when working below 50 per cent. efficiency this law is reversed, and in order to increase the speed or torque it is necessary to increase the strength of the field magnet.

In the articles published a number of methods of accomplishing these results were set forth and two laws, one relating to what is now known as the "long-shunt," and the other to the "short-shunt" machine were given. In your issue of November 26th, Prof. Silvanus Thompson referring to the Sprague laws of winding motors to be self-regulating, quotes the law for the long-shunt machine, and says further: "Will you permit me to point out that this identical law was published in the summer of 1884 in the first edition of my work on 'Dynamo-Electric Machinery,' p. 367, equation No. LIV. (or page 451 of the second edition) where it is given as a mere development of the well-known theory of self-regulating motor of Profs. Ayrton and Perry, published in May, 1883. If the law is anybody's it is Profs. Ayrton and Perry's, not Mr. Sprague's law."

Profs. Ayrton and Perry in closing an article in support of the theory that "in a motor the armature ought to be magnetically much more important relatively to the field magnet than in a dynamo" say: "Our practice of obtaining constant speed by the employment of differential winding has been called superfluous, and yet it was re-invented in France last year by Mons. Deprez, in America this year by Mr. Sprague, and has been made the subject of a very exhaustive series of experiments by Dr. Frölich in Germany in 1885.

Mr. Mordey in your issue of December 24th, in answer to Profs. Ayrton and Perry on some other matters, makes the following statement:—

"Profs. Ayrton and Perry refer to Sprague's re-invention of their differential winding. I may be allowed to mention that Sprague's claim to having last year (1885) discovered the principle of inverse variation of strength of field for purposes of regulation is ridiculous, in face of Ayrton and Perry's differential system, and that two years and a half ago I and my assistant, Mr. Watson, patented a system of regulation which, although summational instead of differential, was based on the principle of inverse variation of field excitation. Poor Mr. Sprague, not the Sprague of Birmingham, but of New York, is to be condoled with on having taken out patents (1) for a law of nature probably known previously to all workers with motors, namely, that a shunt motor runs quicker when the field is weakened, and (2) for winding the coils of motors according to the mathematical proportion published in 1884 by Prof. S. P. Thompson in Equation LIV. of his book!"

In your issue of February 25th, Prof. Silvanus Thompson apparently purposely avoided the challenge which I made to him, and among other statements makes the following:

"In 1882, a date at which Lieut. Sprague was, I believe, in England, Profs. Ayrton and Perry patented the regulation of motors by the process of using a differential shunt and series winding; they also enunciated in that year and the year following the mathematical theory of this kind of winding. That theory I expounded and developed in my work on dynamo-electric machinery, published in August, 1884. . . . . The article further gave a certain equation as 'the Sprague law of winding,' and that equation differs in no way, except in the mere symbol employed, from one of the equations (No. LIV.) given in my book. When I read this article, in justice to Profs. Ayrton and Perry, I pointed out that the 'Sprague law of winding' was simply identical with the Ayrton and Perry law of winding. Profs. Ayrton and Perry also noted the point. So did my friend, Mr. W. Mordey, whose experience and authority on motor matters are well known, and he poked a little quiet fun at Lieut. Sprague, condoling with him on the misfortune that he had patented what was previously well known."

After taking exception to the umpires whom I suggested, Prof. Thompson asks: "What are the umpires to decide? Which motor runs coolest? Which motor developes most horse-power per pound weight? Which motor has the highest economical efficiency? Which motor gives the best regulation under all sorts of loads? No man in his senses will enter into competition before he knows what is the issue to be competed for."

Prof. Thompson further suggests: "But if it is true that the Sprague mare has been borrowed from the Ayrton and Perry stable, then no amount of betting that she will lick all creation is of the smallest use; if she beats every other creature on earth, *that will not prove that she was not borrowed.*"

Just here, before correcting this gentleman on facts, I wish to tell him that if he had not purposely and wilfully avoided the plain meaning of the challenge which I made to him, however much he might criticise or dispute as to whether one or more laws should be called "Sprague laws" or "Thompson laws," or "Ayrton and Perry laws," he could not have made the suggestion that the machine I proposed to submit to these judges should be built on any Ayrton and Perry law because the Ayrton and Perry law was described in 1883; and I said as plainly as the English language will permit that I would build these machines absolutely on the models of 1881. Now, whatever method

of regulation I used, or however they were built, they would not depend upon any statements that Prof. Thompson or Profs. Ayrton and Perry have enunciated to my knowledge, or, if similar to anything of theirs, I would prove to the satisfaction of the men who would be the judges of this my absolute right to whatever credit there was in these machines. Prof. Thompson could very well have separated his discussion, as I did, from Ayrton and Perry's theories and the credit which he, or Profs. Ayrton and Perry, or myself might be entitled to from the discussion of my proposition. This was a plain, unequivocal challenge in very plain and unequivocal language; and, since the affirmative statement was not sufficient, I will tell Prof. Thompson that I will build in competition a machine either on the model of 1881, which was the only one referred to in this challenge, or on the models of 1887, and that neither machine will depend upon him or his theories, or upon Prof. Ayrton or his as he enunciated them in 1883; it will, to borrow the simile, be a Sprague mare, raised and bred in a Sprague stable, and in any weather or in any condition of track will be entered to win.

I shall show the incorrectness and, as it seems to me, either the gross ignorance or wilful misrepresentations of certain statements which have been made. Let us see what Profs. Ayrton and Perry did in 1882 and 1883. The first patent which I have been able to find of Prof. Ayrton relating to this subject is that of which a complete specification was filed in December, 1882. When it was made public I do not know, because I am not sufficiently familiar with the methods of procedure in the English Patent Office at that time, but reference is generally made to their paper before the Society of Telegraph Engineers, May, 1883. After describing several impracticable methods of governing the speed, they go on to describe their particular differential method in the following words:—

"Another method which we employ consists in the use of a magneto-electric machine; the field magnet is made permanently a magnet, but it is also wound with a coil of wire which is in the same circuit as the armature, and whose effect is to diminish the magnetism of the permanent magnet when the current passes through the motor. The dynamo part helps the current and uses up mechanical energy, thus acting as a "governor" to the magneto part, which is really a motor, and which converts electrical energy into mechanical energy. A magneto machine, gearing into a very much smaller dynamo machine, both in the same circuit and regarded as one motor, may also be used. In any case the constant electromotive force which is maintained exter nally, the resistance and constant of the machine or the machines, and the speed, are matters we determine very accurately by means similar to those described in the above-mentioned patent specification, No. 55 (1882). A shunted motor may also be employed, that is, a shunt circuit is coiled on the field magnet and produces a permanent magnetic effect, but there is also a coil on the field magnet which is in series with the armature, and which is so arranged that when the current passes the magnetism is weakened."

They then describe certain methods for the determination of the winding for this motor, which is based upon the electromotive force which the machine will develop with some particular speed and winding, and then give a series of equations and actual winding based upon the space required by the wire and certain relations of resistances (page 8, lines 13 to 21), to which I shall make reference later. On page 11 is found the claim covering this as follows:—

"The construction of a motor whose field magnet is mainly wound with a shunt circuit to the whole machine, but is also partially wound with wire in the same circuit as the armature in such a way that the current diminishes the magnetism produced by the shunt circuit, for the purpose of obtaining constant speed independently of the load when there is a constant or a nearly constant difference of potentials maintained between the terminals of the motors, or when there is a constant or a nearly constant current supplied through the motor, substantially as described." This is a description, pure and simple, of what is now known as a long-shunt machine, that is, a machine which has one fixed component in the field magnets and one variable which is dependent upon the armature. They propose the utilisation of the short-shunt machine (which actual connections, of course, are not new with Ayrton and Perry), for regulation on a *constant-current circuit*, but do not claim it, do not describe it, do not in any way set it forth as being of use when properly proportioned for the purpose of regulation on a constant potential circuit, on which, of course, the conditions are entirely different.

To see if this view of their patent is the correct one, let us look at the description of their machines which they gave before the Society of Telegraph-Engineers and Electricians, and which is quoted at length in your issues of August 18th, 26th, September 1st, 8th, 15th and 22nd, 1886; the article which has particular reference to this matter is found in the issue of August 18th, to which I beg to call particular attention. The class of machine to be used on constant potential circuits by Profs. Ayrton and Perry is diagrammed very clearly in figs. 8 and 13. They here give the key to their line of reasoning when they say:—"This combination of motor and generator brake is the gist of our method, and the exact combination we employ in any particular case depends upon what are the supply conditions, that is to say, whether constant difference of potential is kept up at the terminals of the motor, or constant current is passing through the motors."

They go on to state, in describing the long shunt machine, that it is to "be remembered that the supply condition we are dealing with is 'constant difference of potentials at the terminals of the motor;' hence, the current which passes through the shunt circuit will be a constant current, and the iron of the field magnet, so far as this current is concerned, will act as a permanent magnet. The current then passing through the shunt circuit magnetises the field magnet, as shown in the figure, but, in addition, the wire which forms part of the armature is wound round this field magnet in such a way that the current passing through it tends to demagnetise the field magnet, and here, as before, the armature and shunt circuit act as a motor, while the armature and the thick wire coil, which is a continuation of the armature, and which is wrapped round the field magnet, form a brake dynamo."

This, when we take into account also the description they give for constant current machines and the state of the art at that time, fixes very clearly exactly how far Profs. Ayrton and Perry went in their theory and exactly what they meant by it. I have no wish to detract from the credit due to Profs. Ayrton and Perry for their ingenious methods and for the work which they have done in advancing the transmission of power; but they have made some very serious mistakes in its practical application, and I differ radically from them in the principles which should govern the construction of a motor. While ready to accord to them every credit which is theirs, I cannot, either in justice to myself or anyone else, assign to them, as Prof. Thompson has done, a consideration of the subject in a light in which they apparently never did regard it; a series of laws which do not and never have characterised the construction of their machines, and methods of connection for certain purposes which they never proposed, either in their patents or in their descriptions, and which they have never yet used in any machine which they have constructed.

As I have pointed out, Profs. Ayrton and Perry, in considering the regulation of the motor, considered it as a combination of two machines, one as a motor and the other as a brake dynamo, the armature being driven as a motor in a constant and permanent field and as a dynamo in a field produced by a coil in series with itself and with itself only. I think that this view of the case prevented Profs. Ayrton and Perry from seeing that, by using two variables instead of one variable and one permanent function in the field magnets precisely similar results could be obtained and that in the use of two variables there would be opened up a large

variety of special combinations. On the contrary, I considered purely and simply the question of the amount of power developed by the motor, its relation to the current and to the motor, or counter, electromotive force, and upon what this counter electromotive force depended; and there resulted from these considerations what Prof. Thompson has pointed out, that both the long shunt and short shunt machine could be utilised for regulation; and I developed the following forms:

The plain shunt machine, with hand or mechanically automatic variation of field magnet strength—that is, a machine having one variable component in the field.

Then the long-shunt with symmetrical field, the long-shunt with distorted differential field, the right-angled winding, in which the coarse and fine fields set up polarities at right angles to each other. These three varieties have one fixed and one variable function in the field magnets, the governing coil opposing the action of the fine coil, in one case directly and in the others in a distorted manner.

I further developed the short-shunt, the combined long and short shunt, the distorted cumulative and differential windings both for long, short, and combined long and short shunt machines, and the Wheatstone Bridge machine. In these last varieties the field has two variable components.

Not one of those forms, except the long-shunt machine, was ever used as a self-regulating motor on a constant potential circuit until I used them.

Prof. Thompson, in the second edition of his book, in a foot-note on page 433, speaks of the Ayrton and Perry machine as having windings "combined with an independent constant magnetism."

In addition to these varieties there were several others which had different methods of hand and automatic control. In the automatic machines, of course, the ultimate object of all these methods is to weaken the motor electromotive force of the motor when the load is increased, provided we are working on the first or highest economy; and since none of these forms of motors existed before Messrs. Ayrton and Perry or myself developed them, it follows that the specific laws and connections, by means of which the motors should be constructed, are the things which, in themselves, constitute invention, and for which those who devised them are entitled to credit.

It can hardly be supposed, despite Prof. Thompson's assertion, that, had Profs. Ayrton and Perry fully understood these different connections and realised that they could be used on a constant potential circuit, that in a patent which is so full of details, and in a description so elaborate as that read before the Society of Telegraph Engineers, they would not have mentioned and claimed these various combinations. Few persons will admit this for a moment, nor do I believe that Profs. Ayrton and Perry, on a thorough consideration of this subject, would themselves claim it, although it is claimed for them.

As I have stated, there are, of course, several laws of winding, these laws of winding being simply questions of proportion which pertain to these different varieties of machine, one being for the long, another for the short-shunt, another for the combined, and others for the distorted windings; and these depend upon the types of machines. Two only were given in the articles referred to on the Sprague motors, which article was published in your journal. One was called the "first" and the other the "second" law of winding. One was for the long shunt; the other for the short shunt. Prof. Thompson ignored the second law of winding, which is, in some respects, a much prettier law than the first. In the long-shunt machines the winding depends upon the resistance of the series coil; in the short-shunt machine it is independent of the resistance of this coil. Let me go further; I will show that the actual proportions of winding, even in the long-shunt machine, which were first publicly proposed by Prof. Ayrton, do not and cannot be the same as would obtain in the machines of the construction adopted by the writer.

Two distinct theories have been advanced for the proper construction of motors. One is advocated and ably defended by Profs. Ayrton and Perry, and is to the effect that different general principles should govern the construction of dynamos and motors; that in the former the field moment should greatly predominate over that of the armature, while in motors the moment of armature should greatly predominate over that of the field. On the other hand, I think I am right in stating that Prof. Rowland, Dr. Hopkinson, Messrs. Mordey and Kapp hold with myself the opinion that the best apparatus for converting mechanical power into electricity must necessarily be the best apparatus for converting electricity into mechanical power, and that the principles governing the best electrical construction of one must also be the best for constructing the other. In short, in motors, as well as in dynamos, we should aim to have the most intense magnetic field possible, the lowest armature resistance practicable, and the greatest ratio between the magnetic moment of the field and the armature which the construction of the machine will permit. It is true that the great varieties of work demanded of motors make their construction often different from dynamos: but this does not affect the truth of the principle involved.

It was pointed out in the article that both in the long and short shunt and combined windings, if the circuit were closed to the machine in its normal condition the proportions of the windings were such that there would be an absolutely dead field, the ampère turns in the series and shunt coils being exactly equal.

If we refer to Prof. Thompson's work, we find on page 452 of the second edition the following statement:—"There is, however, one serious difficulty presented in the workings of the differentially-wound motors constructed on the theories of Prof. Ayrton and Perry; if the current is suddenly turned on to start them, seeing that the armature is standing still and is not developing a counter electromotive force, the greater part of the current runs through the armature and series coil, and very little through the shunt. The result is that the shunt coil, which ought to provide the chief part of the magnetising, is less powerful than the demagnetising series coil, and the motor starts the wrong way."

In other words, according to Prof. Thompson the ampère turns of this series coil are greater than the ampère turns of the shunt coil; that is, the weakening action of the series coil of the armature is greater than should exist. In fact, the actual machines as constructed are not wound in accordance with any of the laws which I have enunciated, but since Prof. Thompson has been so inaccurate in describing other matters, it may be that this description of the Ayrton and Perry motor is itself inaccurate, although he can hardly be mistaken about the direction of rotation. Hence we will turn to the English patent already referred to, and take Messrs. Ayrton and Perry's own words as found on page 9, lines 13—21, as follows:—

"Let us make R = 0·16 and N = 1,000. Also arrange that the regulating coil is to occupy one-fifth of the field magnet coil space, then $y = 5$, and $x = 1{\cdot}25$, so we find that $b = 0{\cdot}053$ and $a = 0{\cdot}113$. K = 0·00016 and $\rho = 0{\cdot}000132$ ohms. When, therefore, the regulating coil, ρ, has this resistance and occupies one-fifth of the volume of the field magnet winding; and when the shunt part occupies four times as much of the equally useful volume, and has a resistance of 100 ohms: when armature resistance together with that of regulating coil is 0·1601 ohms, this motor will run at 100 revolutions if a constant difference of potential of 100 volts is maintained between its terminals."

This is explicit enough, and it is to be presumed that these gentlemen knew as much about this winding of their machines as anyone else, and hence we may make a few deductions from the above.

If the coarse and fine coils have the same mean lengths of turn, and the ratios of thickness of insulation to cross sections of wire are equal, then we have, with the above proportion of space occupied, letting m and n represent the number of turns of fine and coarse

wire, the ratio of resistance necessarily expressed by the equation $\frac{m^2}{4n^2}$, and substituting the values given, we have

$$\frac{m}{n} = 2\sqrt{\frac{r}{\rho}} = 2\sqrt{\frac{100}{\cdot000132}} = 1{,}740.$$

Referring to the first Sprague law, we find that with the resistance given we ought to have

$$\frac{m}{n} = \frac{r}{R + \rho} = \frac{100}{\cdot1601} = 625.$$

Are these figures, 1,740 against 625, sufficiently explicit to show the inaccuracy of Prof. Thompson's statement that the first *law of winding* is an Ayrton and Perry law? The second method not having been used by these gentlemen for this purpose, I cannot make any comparison of figures to show variations of their practice from the second law; but if a motor of their type were thus connected, it would be wound as demanded by the second Sprague law. It seems then that, notwithstanding Prof. Thompson's self abnegation, the question of priority of statement of this first law (there is none about the second) lies between himself and me, and since he has practically intimated that I am indebted to him for his knowledge, I may as well dispose of this at once.

In 1884, before the first edition of Mr. Thompson's work on dynamo-electric machinery appeared, he favoured this country with a visit. While here and attending the Electrical Exhibition at Philadelphia, he came across a little exhibit of motors made by the writer. They were seven in number, differing somewhat in type and characteristics, and varying from 1½ to 6-H.P., all of high efficiencies. The mention of the characteristics of these machines in the catalogue might well attract the attention of the scientific student, for here were motors for constant potential and constant current circuits; motors to run automatically at constant or variable speed; constant speed motors, which could be started under a load gradually, and would run with fixed brushes without sparking; a motor which could be set to run at different constant speeds, and to run in either direction, and a motor which could be run fast or slow, forwards or backwards, capable of reversal when running at a high speed without a sign of a spark, and presenting some other peculiarities, such as the converse or direct variation of field strength to get increase of speed, or torque, when working above or below the 50 per cent. limit.

When, after some general conversation on the subject of motors, Prof. Thompson suggested that I explain the construction of the machines, I declined because of patent complications, making an exception, however, in the case of the last-named machine, which I thought I quite fully explained. This machine, intended for demonstrating the possibilities of motors for variable work, had no attachments for controlling automatically the speed. How erroneous an idea of the subject Prof. Thompson got may be seen by the entirely incorrect statement that appears on p. 447 of his 1886 edition, as follows:—

"Motors governed on this principle (Wheatstone bridge) have more lately been constructed by Mr. F. J. Sprague. They show remarkably good regulation."

I may as well state now for Prof. Thompson's information that the motors which ran at so constant a speed were constructed with a distorted differential winding on one of my own laws.

In referring to his 1884 edition, as containing the first law of winding, Prof. Thompson, probably unwittingly, lays himself open to the charge of inaccuracy.

Turning to this reference, we find on p. 367, equation LIV., as follows:

$$\frac{z}{s} = \frac{r_a + r_m}{r_s},$$

and referring to p. 180 for a translation of the symbols, we find the law to be as follows:

The number of turns of wire in the shunt field is to the number in the series field as the sum of the resistance of the armature and series field is to the resistance of the shunt field.

This is the exact reverse of my law, and a machine so wound would begin to run faster the moment the load was put on it, would increase very rapidly and then suddenly stop, reverse and run backwards at a slower speed.

In this second edition of his work, published in 1886, while using identically the same symbols on p. 242 as in the previous edition, Mr. Thompson on p. 451, gives the proper law by inverting one member of the equation as follows:

$$\frac{s}{z} = \frac{r_a + r_m}{r_s}.$$

Possibly Prof. Thompson may plead that this was an oversight, or a typographical error, as it probably was. In view of the fact that the change was made in the second edition, and that reference was nevertheless made in his criticism to both editions, would not candour and fairness have led Prof. Thompson to make some reference to a change with which he must have been familiar.

And now as to Mr. Mordey: His definition of the principles I have enunciated, being meagre and inaccurate, is misleading, and reference to existing works on the subject of motors will not bear him out. My statement was not simply that a motor will run faster with a weak field than with a strong one, nor is it necessary that it shall so act. The conditions under which a motor is running determine whether a weakening of the field will make it run faster or slower. The principle in its broad sense is as I have already given it, and was first enunciated by me.

Mr. Mordey cannot rightly treat this in the light of to-day, when motors have been brought to very high efficiencies.

How little the principle was generally understood may be seen from the fact that Prof. Thompson has never yet published it, and the nearest reference he has made to it is found in his 1886 edition on page 456, where, referring to the experiments of Messrs. Mordey and Watson, these words appear:—

"With a lower electromotive force, the same motor regulated shunt almost equally well, but at a lower speed. It was observed that, especially when the motor was giving out small horse-power, its speed was increased by *weakening* the field." Why this surprise?

How *important* the principle is may be inferred from the fact that the published commercial efficiency of the Ayrton and Perry motor in 1884 was 35 per cent., which shows that when developing its full normal power the armature must have been working dangerously near the 50 per cent. limit, while with the present efficiency of the motors developed on my own principles they would be theoretically run at a constant speed and full normal load with the potential dropping from 220 to 90 volts.

In 1886 Mr. Mordey published an account of some interesting experimonts showing that a motor properly designed, having an intense magnetic field, and an armature of very low resistance and magnetic moment, will regulate very closely under varying loads. This has been called a discovery. It might better be termed a true development of the correct principles of motor construction.

Precisely similar results have been developed in my own practice, and in a perfectly independent manner, but I certainly would not presume to question the originality of Mr. Mordey's work whatever its relative novelty may have been. He has seen fit to publish his experiments; I have deemed it best to keep my own practice to myself, not only in this but in many other lines, as all manufacturers must do for their own protection; and yet I have large numbers of shunt machines running to-day depending solely for their governing upon the proportions of the machine, and the slight weakening of the field produced by the reactions of the armature. Since Mr. Mordey has made reference to past dates, I may as well mention that in

the early part of 1883, he will find that there was filed in the United States Patent Office a machine invented originally when I was in France, one form of which operated to run at a constant speed by raising the potential existing at the armature and at the same time reducing the cumulative action of coils in series with armature. These were also arranged so that they could be made either differential or cumulative.

I regret that this reply has been necessarily so long, for I have no desire to needlessly encroach upon your valuable space, nor have I either the time or inclination to enter into an interminable discussion. The facts are simply as I have stated them. The public, and in time the courts, can decide as to them. When, however, Prof. Thompson, or any of the other gentlemen who have been mentioned in this discussion escape from the confines of the British Isle to this benighted country, they will find myself and associates entirely willing now to show them original models if they wish to indulge in research, or, on the other hand, the most extensive and varied existing application of motors to the Arts.

F. J. Sprague.

New York, *November*, 1887.

[The two last equations in the above communication are printed as written.—EDS. ELEC. REV.]

Legal.

Our attention has been called to a paragraph in your issue of the 16th inst. containing comments upon the action of "The Maxim-Weston Electric Company, Limited, *v.* Crisp and Company," which is calculated to prejudice the fair trial of the case.

As solicitors for the defendants, Messrs. Crisp and Company, we beg to inform you that the paragraph in question was inserted without either our or our clients' knowledge or consent, and was wholly unauthorised by us or our clients, and we have, therefore, to ask you to insert this letter in your next issue, and to refrain in future from making any further observations whilst the matters in dispute are *sub judice*.

Hubbard, Son and Eve.

March 28th, 1888.

[We insert this letter with mixed feelings of pleasure and regret—pleasure at being able to exonerate our correspondents from the slightest suspicion of having favoured the REVIEW with items of news, and regret that we were forgetful that the case was still *sub judice*; but we fail to see how our note could possibly affect the position of Messrs. Crisp and Company. No doubt, however, the above communication was written with a definite object in view, inspired perhaps in another quarter entirely.—EDS. ELEC. REV.]

Lapsed Patents.

We observe a paragraph in your issue of the 23rd inst. calling attention to the lapse of patent No. 4,886, 1880, J. Hopkinson and another, and asking, "How does this affect the Edison-Hopkinson dynamo?" As sole makers of the Edison-Hopkinson dynamo and licensees under the patents of Mr. Edison and Dr. Jno. Hopkinson, we desire to point out that the patent you refer to relates to a form of dynamo altogether antecedent to the Edison-Hopkinson type. All the patents relating to the latter machine have been maintained.

Mather & Platt.

March 28th, 1888.

Magnetic Resistance.

In spite of Mr. Swinburne's vigorous attack on the term "magnetic resistance," there are, I think, many reasons why it should be retained. The fact that it was proposed by a man of such unfailing scientific instinct as Faraday should incline us to be loth to condemn it. It is to the analogy between the electric and magnetic circuits that we owe the abandonment of all those theories (such as Poisson's, for instance) which take account only of the strength of the original field in which the iron is placed, and assume, in fact, that the induction is the same whether the iron is in the form of a straight bar or a closed ring embracing the magnetising coils; the application of a clumsy conformation coefficient being the only method of correcting this absurdity. This analogy was ably worked out by Mr. Bosanquet in a series of papers to the *Philosophical Magazine*. The general theory propounded by him is of immense assistance to anyone striving to grasp the main principles of magnetism.

As regards the general advisability of the adoption of such a term, I take it that the main object of terms is to assist in clearing our ideas. To a man whose ideas are perfectly clear, a mere matter of terms is of little or no importance, and for such an one to stickle at a term which is of great assistance to his weaker brother, because it does adequately express the whole of the facts of a very complicated phenomenon, is, I think, a little pedantic.

With reference to the analogy of the copper ring in mercury. In this case "the circuit" fills the whole of the space surrounding the coiling magnet, and both its resistance and the current in it are perfectly definite. We must not choose an arbitrary portion of that space and complain that Ohm's law is useless because the current past all sections of this arbitrarily chosen circuit is not constant. If the resistance experienced by the current passing through any given area in the space is required we must follow the lines of flow, and so mark out a circuit throughout which the "solenoidal condition" is satisfied. The resistance of this can then be calculated from its specific resistance and dimensions, and of course will equal total E.M.F. current through given area. If the air were to become conducting to-morrow, Mr. Swinburne surely does not mean to say that electrical resistance would become a "vague and misleading term." All electrical problems, though immensely complicated, would still have definite solutions.

Concerning the proposed substitution of permeability, or rather its reciprocal "impermeability" for magnetic resistance. I remember some years ago seeing a similar proposal made with regard to the term electrical resistance, which was alleged to have no physical meaning, being merely the reciprocal of conductivity. Yet the term has survived.

The objection that magnetic and electric resistances are not of the same dimensions cannot, I think, be pressed very hard with any consistency. For it may be answered that an electromotive force is not a force at all having different dimensions; that an electrical resistance having the same dimensions as a velocity does not correspond to a mechanical resistance; and, finally, that an electrical current is very probably not accompanied by a transfer of anything *along the conductor*.

I am inclined to think that a good deal of Mr. Swinburne's objections may be due to his differing from Mr. Bosanquet in his definition of magnetising force. Magnetomotive force ($4\pi nc$) is the line integral of the magnetic intensity taken once round the circuit. This magnetic intensity is what I think Mr. Swinburne calls magnetising force, being difference of magnetic potential *per unit length*. In the same way Mr. Swinburne's electromotive force differs from what I think most people call electromotive force, namely, difference of electric potential. It is difficult to see how, in an air-iron circuit, the magnetising force in the *iron* is to be found without the idea of magnetic resistance, the whole magnetomotive force ($4\pi nc$) being distributed over the different parts of the circuit in proportion to their resistances. How does Mr. Swinburne get over this difficulty?

In conclusion I would say that, although the phenomenon of hysteresis shows conclusively that iron does not play the purely passive part in increasing induction that the term low resistance would imply, yet, by working on this theory, we are led into no inconsistency, either qualitative or quantitative. Until, therefore, something more definite is known of the nature of induction in iron, it is rather premature to dispense with the term "magnetic resistance."

R. H. Housman.

March 27th, 1888.

Telephone Patents.

As certain dealers in electro-magnetic telephones are utilising the newspaper reports of the recent case, "The United Telephone Company *versus* The Equitable Telephone Association," as a means of pushing their business, pointing out that their instruments employ no *carbon*, while it is the *carbon* transmitters of the Equitable Telephone Association that is specially attacked, it is well that the public should be informed that these said newspaper reports are in this case, as is frequent when the daily papers attempt to handle scientific matters, calculated to convey very erroneous impressions.

As a matter of fact, the United Company are attacking the receiver used by the Equitable Telephone Association quite as much as the transmitter; and if their contentions can be upheld, all the "membrane" telephones now in the market are equally infringements.

A. A. Campbell Swinton.

April 3rd, 1888.

Electrical Locomotion.

I observe with pleasure your spirited article on the above subject in your current issue.

You can do no greater service to electrical engineering interests, both commercial and professional (if there be any real distinction), than by pushing to the front what is beyond serious question not only the most promising branch of heavy electric work, but also that branch of engineering which has in it greater immediate possibilities as an *enormous* industry than any other, a bold statement probably, but figures, statistics, and practical inquiry prove it.

I dare say, owing to circumstances, I am more familiar with the commercial aspects as they affect the work, and the way it may be carried out on a large scale, than most. I have in my mind now the phases of negotiations that I have had with several of the largest tramway companies in this country. I will be bold enough to attempt a solution of the question you profess your inability to answer, viz., "How to account for this hesitancy in taking up so promising a concern we know not."

What are the present facts in connection with electrical locomotion, from the manufacturing points of view? They are these: the manufacturer is ready to supply plant, with or without accumulators, at such prices, and to undertake the yearly maintenance at such rates for depreciation, that the cost per car mile comes to a very low figure as compared with horses *or steam*, where the number of cars is large. But the manufacturer wants orders; he has not got the capital to lock up in plant; if he had, it is not his proper function. Now where are those orders to come from? It will be a long time before tramway companies generally begin to actively equip their roads with electric appliances, *if they use their own capital for the purpose.*

In one of the negotiations that I referred to above it was offered to put down the entire plant and equipment for a considerable number of cars free of any capital outlay to the tramway company, and to run the cars for two years at a reduced price on the present cost. Then the tramway company were to purchase the plant after absolute proof of its economy; at the time of the purchase the plant was to be in a state *equal to new.* When the tramway company had purchased the plant they would have saved the yearly profit we should have made on the *reduced* rate we offered them, and including all depreciation, which would have been guaranteed (or taken and contracted for), interest on a somewhat larger capital than used with horses, they would still have saved over £2,000 a year on a comparatively small number of cars.

You may well ask if a tramway company won't accept an offer like this from a strong contractor (ready to deposit security), what would it accept? In another case a suggestion was made to run a small number of cars at a mileage contract; in this case the company wanted some one else to do the same thing first. Generally speaking, they want "to watch and see what others do."

In the United States of America tramway men see a new and economical power available, and they go ahead and apply it, make a success, and earn their increased dividends, whilst in this country tramway men are devoid, generally speaking, of the initiative and energy necessary to give their shareholders such advantages, and are simply "waiting to see," until one fine day they will all follow in the track of electric traction like sheep; but it won't pay electrical locomotion interests to await that time.

So much for the way tramway companies look at the matter. Now as to outside capitalists. You appeal to a sentiment which I venture to say does not exist in any great force, generally speaking; there are exceptions, but the exceptions cannot do all themselves; at all events, exceptions cannot carry such an enormous industry as electrical locomotion, must quickly be on their backs. As regards saving to be effected, there is no doubt that on present prices it can be guaranteed by manufacturers that a large tramway company running over 200 cars could—if it did the work on its own capital re-arranged or increased for the purpose—save half the present cost of horses.

Few realise what such statements mean. There is trade for manufacturers, work for large numbers of men of all grades, increased dividends to tramway shareholders, and large and quickly made lumps to stockbrokers, which cannot help coming from a legitimate rise in the value of tram shares.

One farthing per mile saved means an increase of about 2 per cent. dividend to one of the large London tram companies!

Now for an answer to your question. My belief is that *the purely selfish interests of financial men generally have not yet been sufficiently strongly appealed to.* We are all selfish, and until financial men generally are shown something that will be an easily saleable commodity in the open market, after they have spent a certain time and capital on it, they will hold aloof. That, however, can be shown them. What we must aim at is to get electrical locomotion undertakings started on a moderate scale, show a dividend, and then go for an increase of capital wherewith to undertake more work.

Capitalists must also be shown that they can work in association with certain advantages, such as patent rights giving points of vantage, manufacturing rights and associations giving also points of vantage, until their trade is firmly built up on a large base.

There must be an intermediate body of contractors and contracting corporations who, on the one hand, will buy their plant and have its maintenance guaranteed by manufacturers; and, on the other hand, will know that they receive a certain sum per mile from the tramway company over a contract for a reasonable term of years. Between the two figures there is a large profit for those intermediate capitalists who are a necessary link to make electrical locomotion move with sufficient rapidity to be something more than a keenly competed cut priced business.

Radcliffe Ward.

April 3rd, 1888.

I was greatly interested by your article on this subject in last week's number, but I do not altogether share in the surprise you express at the slowness with which the matter is taken up by tramway companies: from an outsider's point of view their attitude seems a very natural one. At the present time tramways are not in a very flourishing condition; large dividends are very few: in many cases it is only by the most rigid economy that a dividend can be earned; and in many other cases it cannot be got at all. I believe you are quite right in thinking that the cure for this lamentable state of affairs will be found in using electrical methods of traction; but where are the proofs that would make this certain?

I am not a tramway manager, but during the last few years I have had some opportunities of acquiring a knowledge of tramways and the methods of working the traffic upon them; to the best of my ability I have also closely watched the efforts that have been made to apply electricity to this work. I think tramway managers must be well aware that electricity can now be successfully used on tramways; the only question with them is as to whether it will be as cheap as or cheaper than the methods which they now use; these are practically only two, steam locomotives and horses.

In considering the policy of substituting electricity for his existing methods of traction, the tramway manager who is not simply bent on "making experiments" will naturally want to know what has been done with it in other places. Let us refer to a few of them. Brighton? Bessbrook? Portrush? These are all successful in their way, but they are not "tramways;" they are not such roads as could be constructed in the streets of a town, and although the experience gained upon them is undoubtedly valuable, the tramway manager would like something more nearly in accordance with what he has to deal with himself. Blackpool? This is better, but the methods of construction adopted in laying down the road and in "maintaining" it have led to difficulties which the cautious manager would not willingly run the risk of incurring.

It may be argued that the faults are now all well known, and would be avoided in constructing a new line. This may be so, but in so far as new plans are adopted, though they might reasonably be expected to be improvements on the old ones, they would still have the elements of an experiment about them. The costs of working the traffic on this line I have seen variously stated at 2½d. to 4d. per car mile, but it is tolerably certain that these low figures were only obtained by making a very inadequate provision for maintaining the line. It would be very interesting to know what the cost of maintaining this tramway would be over and above the cost of maintaining a tramway of ordinary construction. We shall have to wait some time for these figures most probably, but they are of vital importance in considering the question in its economical bearings. The cost of repairs during the first three years of the life of a tramway afford but little clue to what the cost in the second or third period of three years is likely to be.

On turning to secondary batteries, which are far more suitable for general tramway work than any system of continuous conductors, the tramway manager will find that the practical sort of information which he wants to guide him is more scanty even than it is in the other case. He will find plenty of accounts of experiments and trial trips, but the only case (in England) where serious practical work has been attempted is at Stratford. I think more has been done here by the Elieson Company towards applying secondary batteries to the every-day work of tramways than by all the other experimenters put together. The tramway manager, however, will find that there is only an experience of some eight or nine months to go upon; that two cars only have been regularly run, and that half-a-dozen engines have been provided to work them. On going into the cost he will find that this represents a capital outlay of about £3,000, independent of engines in depôt, dynamos, &c., or about £1,500 per car, which is more than double what steam-engines would have cost, and about four times what horses would have cost.

These figures are not encouraging, and you will say that the cost would not be anything like so much as this in applying the system anywhere else. Granted; but until the system has been so applied somewhere at a more reasonable capital outlay, and proved to be successful by a good period of continuous service, the tramway manager not in the mood for experiments will not be anxious to take it up. In saying this I must not be understood as saying anything against the Elieson Company's methods of working; they had a great experiment in hand, and they would have acted very unwisely if they had not proceeded with great caution; any failure would have done them far more injury than a perhaps excessive outlay in plant and a little delay. Secondary batteries are what tramway companies have to come to for working their traffic, and it is now time that the various companies and syndicates interested in pushing them forward abandoned the experimental methods of trial trips and demonstrations for something more nearly akin to the continuous everyday hard work of tramway service.

The account you give of the reception of the Elieson tramcar at Buffalo is very interesting, but it will not convince a tramway manager that secondary batteries are quite ready for him to take up. Here, in prosy Birmingham, we have had many similar scenes of wild enthusiasm on the trial trips of the cable tramway just opened for traffic; we, however, lacked a Buffalo journalist to write them up. The line has now been in use about 10 days, and the enthusiasm has pretty nearly all gone. Very few people now pay for the pleasure of being hauled up Snow Hill by a rope unless they have business in hand that renders it necessary that they should go. It is always easy to get a crowd round anything new that may be shown in the streets of a town, but when the novelty of the thing has worn off the crowd won't come and help to make it a success unless it meets with their requirements at a reasonable cost.

T. A.

Catalogues.

Messrs. W. T. Glover & Co. call attention in your last issue to the copying of their catalogue by other makers and suggest that some other parts of the same catalogue are not as original as they might be.

The following may be one of the curious coincidences which are frequent enough in literature or may illustrate the process of catalogue manufacture. It is a sample only:—

WESTERN ELECTRIC CO. *Catalogue (old). Page 5.*	TELEGRAPH MFG. CO., LD. *Catalogue. Page 33.*
Our magnet cores are made of the best Norway iron, so thoroughly annealed as to avoid as nearly as possible the presence of permanent magnetism.	Our cores are made of the best Swedish iron, thoroughly annealed so as to avoid as nearly as possible the presence of permanent magnetism, and are wound with wire having 98 per cent. of the conductivity of pure copper.
The magnets are wound with wire having 96 to 99 per cent. of the conductivity of pure copper.	
We insulate our own wire in the most thorough manner.	We insulate our own wire in the most careful manner, and finish the greater portion of our work by special machinery.
We prefer to use mahogany in the bases of our instruments for the reason that it takes a high polish and especially, because it is the least liable of all the fancy woods to warp or split.	We prefer to use teak in the bases of our instruments for the reason that it takes a high polish, and especially, because it is the least liable of all the fancy woods to warp or split, but we can use any other timber desired.

It may be remarked that the preference for teak does not last beyond the preface. In the descriptions of the different instruments it will be found that the bases are made of mahogany, as in the originals, the illustrations of which are very faithfully reproduced. These originals account for the greater part of pages 33 to 62, 74 to 79, 88 and 89.

In calling attention to the above coincidences it should in fairness be remembered, that it is a not unusual practice for those who make to supply blocks and descriptions for insertion in the catalogues of those who do not make but may sell. Some of the above may be open to such an explanation.

I will not take up your space by discussing the ethics of the question, but would simply remark that Messrs. Glover might be considered somewhat unreasonable in complaining of such sincere flattery as the complete imitation of their production implies.

J. E. Kingsbury.

April 3rd, 1888.

[A late letter on the same subject will be found in another column.—EDS. ELEC. REV.]